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ROADS FOR THE FUTURE

The perennial contest between the road and the vehicles proposed for travel over it is on again in greater force than at any time in the past. Just now the motor truck user is almost daily increasing the load on his truck and the size of the truck, and he is doing the same with the trailers, which are daily becoming more common, following the English practice of many years.

It has been but a very few years since American roads have been good enough to carry this heavy traffic, and just as soon as they are good enough the heavy loads come.

So far as the truck itself is concerned, this increase in loads has a limit, at least so far as unit pressure on the road is concerned, because the resilient tire, which is necessary to protect the truck-driving machinery from excessive vibration and shocks, has its limit of load which it can carry. Consequently it is comparatively easy to guess what the weights on individual wheels will be and so to design the pavement or road to carry them. Pavement it must be on the main traveled roads because only pavements with good foundations will carry them.

We are beginning to collect data about the relations between amount of traffic and life of road service so that we are better able to compute the life of pavements in terms of amount of traffic. We can approximate the life of a road in years by estimating the future amounts of traffic. Whether one surface is more economical than another, whether a pavement will wear out before the bonds issued to pay its cost have been paid, are questions, the answers to which depend, under these conditions, upon our good judgment in foreseeing the increase in amount, not individual weight, of traffic.

If we are to continue to use our present best pavements on our streets and roads we must limit the weights upon individual wheels, and, particularly on trailers, the character of the tire.

If, as now seems inevitable, motor trucks are to take a large proportion of the local freight business away from the railroads, is it not just and right that this use of the roads by but one class of business be paid for by that business? Should motor trucks with heavy loads not pay heavy enough license fees to cover their wear of the roads? The railroad furnishes its own road-bed and we would think it presumptuous for them to ask the state to build it for their free use. The light motor car pays its share, probably, of the upkeep of the roads and of the extra quality of surface demanded by that traffic. The cost of both is made much higher by the comparatively small number of heavy motor trucks and trailers. The special class of traffic should pay the extra cost of the road to carry it.

If, later, the trailer traffic should develop to such an extent as to demand thru lines of steel runways it should pay for the construction and maintenance.

It is not good business to restrict permanently development in any legitimate direction, but it is good business to put the cost of providing for that development upon the traffic which is growing, and any restrictions put upon that traffic should be only such and for such time as may be necessary to make reasonably accurate estimates of the direction and amount of the development and to design and construct the ways to carry it. It is not yet certain, for example, that, except under very peculiar circumstances, the heaviest loads which have been carried are those which will be found economical to carry on the comparatively small units of truck and trailers. We may not need to find better materials for our roads than our present best when the truck traffic man finds his most economical form of vehicle and weight of load. And we may not be required to put any restrictions on the traffic—other than the few that are required to fit the two parts of the one machine together, the particular transmission gear requiring attention being the tire and the road surface at and under the point of contact.

MAKE IT WATERPROOF

You may have passed it by without remark when you read the paper, but you cannot miss it in the abstract on page 53 when five engineers writing on five different subjects all lay stress on the necessity of waterproofing the road surface. That is why their words on this subject are collected together. We all think we know it, but how many of us do the best we know about it? The new traffic in weight and speed makes waterproofing the road the most important detail in its construction, just as choice of material and foundation are the most important in its design.

STREET AND ROAD PAVEMENTS

THEIR DESIGN, CONSTRUCTION AND MAINTENANCE

EDITED BY CHARLES CARROLL BROWN, M. AM. SOC. C. E.

THE DESIGN OF BITUMINOUS PAVEMENTS

By the Editor.

The use of asphalt mixtures for the surfaces of pavements began over fifty years ago with the use of asphaltic limestone or sandstone in Europe and has developed until the bituminous pavement in all its various forms together is the most widely used of any.

Beginning in this country with the asphalt-sand mixture to which the term asphalt pavement has been applied, using natural asphalt, boiled to remove the water, the number of materials with which asphalt is mixed, the kinds of bitumen, asphalt or tar, the proportions and methods of treatment have become legion.

It is true that the most satisfactory compounds thus far used have been those approaching the original limestone-asphalt rock and the original sand-asphalt mixture, with improvements developed in practice, and this article is mainly devoted to those two classes of pavement, the more detailed discussion of others being left to future articles in this series.

NO TIME will be spent in discussing the differences in chemical and physical properties of bitumens other than may become necessary in special cases. It will be assumed that asphalts are natural in their origin, each one requiring a certain, small or large, amount of refinement or distillation to prepare it for use in or on pavements and that tar is an artificial product of the destructive distillation of organic products, orginally of vegetable origin, tho now mainly occuring as minerals.

The design of bituminous pavements must take into account the differences in composition of these various bitumens, and many of the failures of bituminous pavements have occurred because the designers did not know enough about the qualities of the materials they used, or the proportions and and methods of mixing of the ingredients to give the best results. It must be admitted that the present knowledge of all these matters is far from complete and any new mixture or any new material, whether bitumen or aggregate, must be tested by actual use before the conclusions of theory can be accepted or rejected. This lack of knowledge, while still immense, has been filled to a very great extent by the results of chemical research, observation and experiment, so that it is no longer necessary, as it was twenty-five or thirty years ago, to depend upon the instructions of a few men familiar with the use of certain mixtures of a single class of asphalts with a limited number of combinations of aggregates. Nevertheless, the recurring of the best results is still a matter of expert design and supervision of construction and it is worth the while of any municipality to secure such expert advice with reference to the design and construction of its asphalt pavements. Whether this shall be obtained thru a regular employe of the city with a chemical laboratory, or thru the occasional employment of an outside expert, would depend upon the amount and continuity of the laying of asphalt streets by the city.

Even the experts may make mistakes, because of the large residuum of ignorance regarding many of the complicated problems arising, both chemical and mechanical, but a city is safer with their advice, even if they may sometimes be responsible for failures of pavements.

Classification of Bituminous Pavements.

The varieties of bituminous pavements have become so great in number, and they have been devised in such an independent manner that there has been much confusion in the nomenclature, pavements of the same or like ingredients and methods of mixture receiving different names, according to the method of approach of the designer. The American Society of Municipal Improvements has made earnest efforts to clear up these differences and definitions derived from its standard specifications should be adopted as fixing the standard nomenclature for the various classes. These specifications cover the standard pavements of the various classes which have proved successful for the classes of traffic for which they are designed.

Sheet Asphalt pavement is composed of a binder course of stone or stone and sand with asphalt, on which is placed a wearing surface of sand, limestone or portland cement dust, and asphalt, its prominent characteristic being that its wearing surface is a sand-asphalt mixture with a small proportion of fine stone dust.

Bitulithic pavement is a mixture of stone, sand and bitumen laid and finished with a seal coat of fine material aggregate and bitumen, the leading characteristics being the "inherent stability" of the aggregate and the careful proportionment of ingredients and filling of voids.

Bituminous Concrete pavement is of many varieties, ranging from such mixtures as the so-called topeka and the modification of the topeka mixture adopted by the American Society of Municipal Improvements down a rather indefinite distance, the leading characteristics being that the mineral aggregates are broken stone properly dried and heated and mixed with sufficient bituminous cement practically to fill the voids, the surface being finished with a seal coat. The various grades of bituminous concrete vary from a mixture of broken stone, sand and asphalt, according to definite specifications as to proportions of material of various named sizes, and as to filling of voids, down to plain mixture of broken stone and bituminous cement in which the lowering of the cost of the mixture seems to be the principal purpose and its adaptation to the probable traffic secondary.

Bituminous macadam is usually of the nature of a plain macadam pavement treated with asphalt or oil, sometimes by application to the surface of the completed macadam pavement and sometimes during the processes of construction. The line between bituminous concrete and bituminous maca-

dam is not closely drawn, tho there is a tendency to apply the term bituminous concrete to roads laid by the mixing method and bituminous macadam to those laid by the penetration method. This is not strictly correct, however, because in true bituminous concrete the filling of the voids is an important factor and not all roads laid by the mixing method are properly designed in this regard, so that they are, many of them, really no better constructed than those done by the penetration method, and should be classed as bituminous macadam.

Oiled roads are of any ordinary road material and run from those which are as good as bituminous macadam down to those on which a minimum of oil is used, the object of the latter being to lay the dust and of the more copious treatments to hold the surface materials of the road in place for a greater or less length of time, according to kind and amount of oil used and the changes in temperature and the number and length of rain storms.

The Design of Asphalt Pavements.

The first asphalt roads were constructed of natural asphalt rock, the ingredients of which were in proper proportions to produce reasonably good wearing surfaces. These rock asphalts were limestone or sandstone impregnated with asphalt, When they were not properly proportioned they were brought up to standard by adding the lacking material, whether stone or asphalt, and the fine stone added was either limestone or sandstone, according to which would produce the best wearing surface. Artificial asphalt pavements were developed in this country, using Trinidad asphalt as the base, that material containing a considerable proportion of mineral matter, but not enough to produce a pavement when used by itself. To correct the slipperiness which was a characteristic of the pavements laid with European natural asphaltic limestones, sand was made the principal mineral ingredient, a percentage of finely ground limestone being included, to retain the good qualities of the European pavements.

After some years other natural asphalts were introduced and since the discovery of the qualities of petroleums with asphaltic base many so-called artificial asphalts have been developed, ranging in source from the residuums of petroleum to the heavy asphaltic oils in which the asphalt is the principal product and the light oils are the by-product.

Each asphalt, each flux, each sand, each limestone or cement dust, has its characteristics, and to produce the ideal asphalt pavement they must be known thoroly, and the effect of each upon the others in a mixture must be known quite as thoroly. Asphalt chemistry is an exceedingly complicated study and it has taken fifty years to arrive at our present state of incomplete knowledge. Less time has been taken with the study of the other materials and in some respects their characteristics and effects in the mixtures are not so well known as those of asphalt. It is not surprising, therefore, that many mistakes are made in mixtures and in handling.

In the early days progress was slow because it was not possible to go far from the standard materials and methods without serious results. Sand is the material which should come from the locality of the pavement, if possible, in order to reduce cost, but in those early days it was considered necessary to carry sand many miles from a uniform deposit, the characteristics of which were known, rather than take a near-by sand of less uniformity which had not been tried. This condition has been improved, but many bad pavements are due to lack of expert advice as to the materials to be used, i. e., proper use has not been made of the advance in our knowledge concerning asphalt pavement ingredients. The standard specifications of the American Society of Municipal Improvements give specifications for the qualities of the paving mixture, particularly as to quality of asphalt and proportions of the various ingredients as to materials and the various sizes thereof, being specifications for the pavement rather than specifications for each of the individual ingredients. It will be assumed in this article that these specifications or their equivalent are followed. In several cities they are followed with another provision added, making two classes of asphalt pavements, one in which natural asphalts are used, meaning those requiring a small amount of refining; and one in which artificial asphalts are used, meaning those produced by distilling off the lighter oils, leaving the asphalt as a refined residuum of the process.

The Variables in the Problem.

In designing the mixture for an asphalt street there are a number of variables which must be considered.

A heavily traveled street with too soft a mixture will rut, mark or wave. A lightly traveled street with too hard a surface will crack and then will be disintegrated by water and frost. A coarser sand with softer asphalt and less of it would be needed than on a heavily traveled street. A pavement, devoted to motor traffic, which is somewhat soft will be softened still more by any oil which may drop on it from the passing vehicles and may then rut or wave.

An asphalt pavement hardens with age, and the nature of future traffic must be anticipated. as well as that of the present be considered. A harder mixture is required in a warm climate and a softer mixture in a cold climate for the same conditions of travel.

Temperature of materials in process and of the mixture as delivered on the street are important. A temperature which may be needed for one asphalt will harden another asphalt too much and may even ruin another. A temperature which makes one asphalt so fluid that it separates from the mixture may make another mixture so stiff that it can not be properly raked, rolled or compressed.

Differences in penetration or ductility, or both, of the asphalt used, differences in the amount and grading of stone dust and in the quality and grading of sand all have their effect on these characteristics, and the expert can fit the one to the other if he knows the present traffic, the tendencies of the traffic to change and the possibilities of sudden change upon the improvement of a street or road heretofore unimproved. The design of the mixture is thus largely a matter

SHEET ASPHALT SURFACING OVER OLD BRICK PAVEMENTS ON SIXTH STREET, COLUMBUS, O., 1½-INCH BINDER AND 1½-INCH TOP, 1912.

RESURFACING OLD GRANITE BLOCK PAVEMENT WITH ASPHALT ON THIRTIETH STREET NORTH OF MT. VERNON STREET, COLUMBUS, O., 1915.

of judgment led by an expert knowledge of characteristics of ingredients and mixtures.

Consistency of Asphalt.

The sand in an asphalt pavement wearing surface has no material stability and the stability of the pavement depends upon the stability of the mixture with asphalt, as tempered by the stone dust and such other fine material as it may contain. The penetration of the asphalt cement used in the paving mixture has come to be one common measure of its ability to produce a stable mixture for the wearing surface.

The standard specifications of the American Society of Municipal Improvements provide that the penetration of the asphaltic cement at 77 deg. F., shall be from 30 to 55 for heavy traffic streets and from 55 to 85 for light traffic streets. In each of these classes the variation allowed is 25 to 30 points, and this variation is allowed because the variations on account of sand and asphalt used, stone dust, and climatic conditions are not provided for in the specifications, but are left to the judgment of the designer and he must have this amount of lee-way on account of these various causes for variation.

With horse traffic softer asphalts were suitable, but with motor-driven traffic a harder consistency is required.

A soft pavement will shove, push or roll under the effect of motor-driven wheels and the asphalt pavement for modern traffic must be as hard as it can be made without putting it in danger of cracking from cold weather contraction. Slow-moving, heavily loaded vehicles produce more of the effect than light, swiftly moving automobiles, and the effect is more pronounced on grades. A slight wave is soon expanded by the greater action of the traffic upon the irregular surface thus formed, even tho the wave is at first almost indistinguishable.

It may be necessary to vary penetrations upon the same street on account of differences in grade and differences in kind of traffic. In an article by F. P. Smith, he calls attention to a bituminous concrete pavement on a hill with heavy horse traffic going up which soon developed large waves, whereas on the other side of the street, where the traffic was down hill and was composed of empty trucks and light delivery wagons, there was practically no wave formation. Street car tracks shortly divided the traffic into the two streams.

For a heavy traffic street, largely motor-driven, in the North the penetration would probably range from 30 to 40 and in the South from 5 to 10 points lower so that the pavement would not become too soft in hot weather. A street which is always in the shade should have a softer asphalt-cement than one always open to the sun.

Cold weather cracks disappear in warm weather if they are not filled with street dust to prevent re-union, provided the traffic is sufficient to do the welding. Also, cracks are not so difficult to repair as are rolls or shoves, so that there is a tendency toward harder asphaltic cements. Repairs must be attended to promptly in either case. Into cracks will run water and dirt, and the water and frost will disintegrate the pavement. Shoves and waves will become worse in summer and will spread so as to make larger areas to repair. It is considered by many asphalt engineers that it is safer to err on the side of too hard than too soft a pavement.

Defective or light foundations are the cause of many waves and shoves, since any slight depression in the foundation starts a low spot in the asphalt surface, which rapidly develops into a shove, where one would not otherwise occur.

While these shoves or waves are not numerous in asphalt pavements they are very troublesome when they do occur and sometimes it has been very difficult to ascertain their cause. They are far more common in bituminous concrete and especially in bituminous macadam pavements.

The standard specifications assume a relation between penetration and ductility of an asphalt sample. An asphalt cement having a penetration of 50 deg. F. must have a ductility of not less than 30 at the same temperature and each change of 5 points in penetration must be accompanied by a corresponding change in ductility of 2 centimeters. How close this relation may be is not yet definitely known. The two tests do not follow each other exactly when applied to different asphalts.

Some asphalts are more brittle at low temperatures than others. Some have greater differences at high and low temperatures than others. Some are more liquid than others at high temperatures. All these things must be considered in connection with the conditions under which a given pavement will exist in designing the mixture and deciding what asphalts can be used.

The Binder Course.

The binder course seems to be an essential of the good asphalt pavement. A wide-spread attempt to lay asphalt pavement without binder led to failure. The sand-asphalt mixture does not join thoroly enough with the concrete base, even when that is rough, and the action of traffic on the layer of pavement directly in contact with the concrete is such as to break it or wear it with undue rapidity.

The relative merits of open and closed binders have been discussed fully and not all points in controversy have been fully settled. It is enough to say here that the closed binders, in which the voids in the stone mixture are fairly well filled with asphaltic cement is the most popular at the present time. Asphalt is not a very good conductor of heat, and the wearing surface protects the binder from sudden and even from very great changes in temperature, so that the binder retains its resiliency more uniformly than the surface, and thus aids in keeping the pavement up at all times to its average condition, which is naturally that for which it is designed.

Too soft a binder will exaggerate any tendency in the surface to shove or become wavy and the movability of the

stones in the open binder is one of the objections to its use. Again, if water gets into the binder to stay permanently, whether thru lack of sub-soil drainage, so that water comes up thru the foundation, it finally loses its bond and movement of its parts induces the formation of waves. The foundation and sub-base may be softened even more than the binder coat and thus cause settlement and defects in the surface.

Drainage.

The asphalt pavement is so smooth that the necessity of good surface drainage is not always recognized. The crown should be sufficient to shed water surely in case there may be any slight inequalities due to irregularities in laying or compacting the surface, and may be reduced somewhat as the grade of the street increases, being sure to retain enough to turn the water promptly to the gutters. On streets with practically flat grades, catch basins or sewer inlets should be inserted at intervals between street corners so that the gutters, at least, may have fall enough to carry off the water. The gutters must be kept clean, also. No matter how nearly waterproof the pavement may be there is always chance for water to seep into and under it from pools in the gutter thru the joint between pavement and curb or pavement and gutter, if of other material than asphalt. It will also drain down thru joints in the curb and around inlet castings, posts, manhole covers, etc.

Thoro compression of binder and surface courses by longitudinal, cross and diagonal rolling aids in making the pavement waterproof and in making it a stable unit and should also be demanded in the specifications accompanying the design. Too much attention can not be paid to this detail.

Thickness.

The standard specifications leave the question of thickness of binder and wearing surface to the judgment of the designer, the relative importance of the two under the local conditions being determined by him. In general it may be said that the total thickness of the two is about 3 inches, and that the tendency is to make the wearing surface as thick as possible without reducing the binder enough to lose its effect.

From the tables giving data regarding construction of asphalt pavements in 1916, to be found elsewhere in this number of MUNICIPAL ENGINEERING, it will be seen that the thickness varies in the cities reporting from 1 inch in a single coat in Hazleton, Pa., to 4 inches in Washington.

The variations in distribution of thickness between binder and wearing surface are shown by the following data from 105 cities in the table. Single coat: 1 city uses 1 inch thickness: 2 use 1½; 1, 1½ to 2; 20, 2 in.; and 1, 2 to 3 in. Most of the use of the single course is in Southern states, but it is also used in some cities in Washington and occasionally in other Northern states. Two coats: Binder ¾ in., surface 1½ in., 1 city; 1 and ½, 1 city; 1 and 1½, 21 cities, a popular combination in Ohio, Indiana, Michigan and Iowa; 1 and 2, 14 cities; 1 and 1½ or 2, 3 cities; 1 or 1½ and 2, 1 city; 1 and 1½, 1 city; 1½ and 1, 1 city; 1½ and 1½, 20 cities, 1½ and 2, 11 cities, popular in Illinois, 1½ and 1 to 2½, 1 city; 1 and 1½ or 2, 2 cities; 1 and 2½ in Washington, D. C.,2 and 2 in Nashville, Tenn., on old base; 0 to 1 and 1 to 2, in one city.

The most popular combinations are, single coat 2 inches thick, 20 cities; 1 in. binder and 1½ in. surface, 21 cities; 1½ in. binder and 1½ in. surface, 20 cities. These figures give a very fair idea of the standards of practice in this regard, but no information as to the reasons for adopting these standards.

LAYING BITULITHIC SURFACE OVER OLD MACADAM, COMMONWEALTH AVENUE, NEAR CHARLESGATE WEST, 1916.

THE DESIGN OF THE BITULITHIC PAVEMENT.

The object in the design of the bitulithic pavement is to produce a true bituminous concrete wearing surface, uniform in composition thruout its mass from top to bottom, which has a maximum of density or low percentage of voids in the mineral aggregate, which latter is so graded as to produce an inherent stability in same, independent of the bonding qualities of the bituminous cement, which is used in sufficient quantity to coat all the particles of the mineral aggregate.

The inherent stability of the aggregate is obtained by the interlocking of the bituminous coated particles of mineral aggregate, they keying into each other so as to tend to resist displacement by the strains of traffic, and to obtain this result extreme care must be observed in prescribing the proportion of each size of particles of aggregate to be used.

The screen grading required can not be calculated by any known rule and even Fuller's well known formula for portland cement concrete will not give maximum density in a bituminous concrete. The grading varies with the shape and maximum size of the crushed particles; therefore, a close study should be made of the mineral aggregate using a screen and void tests on which to base a screen grading which gives maximum density and the percentage of bitulithic cement to fill the remaining voids and well seal the surface.

Stone cubes or prisms of equal size could be laid to lock together and produce a maximum of density and inherent stability, but would produce a very inferior wearing surface, quickly abraded and ravelled by traffic. On the other hand, if too little coarse stone and an excess of mortar is used, the mixture is yielding to traffic and, lacking inherent stability, causes trouble by shifting; hence the attempt is to produce a mean, which is appropriate for the traffic.

For instance, on a level road subjected to automobile traffic exclusively a coarser maximum size stone and a larger proportion of same can be safely used than on a similar street exposed exclusively to horse-drawn iron-tired vehicles. Again on a steep hill where a rough surface is of prime importance, the size of the maximum size stone may be increased and the proportion of the mortar decreased, thus causing the coarser particles to protrude somewhat and give better footing for the horses. Great care must be exercised in this, however, as decreasing the mortar to that extent naturally decreases the waterproofness of the surface; hence while this can be done on a steep grade, a change in the mixture back to normal

must be made at the foot of the hill, where the water will not drain off rapidly.

The surface of the pavement can also be made relatively rough or smooth by varying the size of the aggregate used in the surface finish. This finish or seal coat can be applied:

(a) By first rolling the wearing surface until it has received ultimate compression and then covering it with hot bitumen spread by a squeegee machine and covering same with stone chips or coarse sand and rolling.

(b) By first spreading the wearing surface mixture in the usual manner and then before rolling spread over it a very rich mixture of the fine aggregate and seal coat bitumen, and then thoro rolling the seal coat and wearing surface mixture in one operation.

This latter, known as the mixed method seal coat, seems preferable on level streets, and by getting a somewhat better bond with the surface mixture produces a closer, more waterproof and therefore more durable surface.

Mineral Aggregate.

This may be either crushed stone, gravel, crushed oyster shells or any other mineral product which is of durable wearing qualities and has a surface with which the bitumen can become suitably bonded.

The actual screen of a gravel aggregate consisting largely of oval particles will be a very different grading from that used with crushed oyster shells, which when laid on the street lie down flat.

The material used must be clean, such as clay in gravel and inseparable dust in some limestone. If not clean as soon as the seal coat is worn off by traffic and the larger stone surfaces are exposed, the rain and water from sprinkling carts will penetrate these dust shells, tending toward loosening stones from the bituminous mortar and starting ravelling.

A coarse grained granite or trap will shatter under iron-tired vehicles, while a softer but tougher fine-grained trap or limestone will wear down evenly. All laminated stones are to be avoided since if they happen to be exposed with the laminations vertical, they are liable to absorb water rapidly and shatter under traffic.

Bitumen.

Bitulithic cement is a blending of high grade asphalts in an endeavor to obtain the good points and discard the weaknesses of each.

The quantity used in the mixture depends upon:

(a) The percentage of voids in the aggregate;

(b) The character of the aggregate;

(c) The maximum size stone used.

For instance, in a limestone mixture the screenings in the mortar "eat up" more bitumen than can be carried by the fine sand in a straight gravel mixture. Again, in a mixture using 1¼-in. as a maximum size of aggregate there is less mortar used than when using ¾-in. as a maximum, since the total surface area of the aggregate in the former is less and less bitumen is required to cover it. However, as a general rule 7-8 per cent. of bitumen by weight is used in the surface mixture exclusive of the seal coat. This at first sight seems to be much less than the usual 10 per cent. bitumen in sheet asphalt mixtures, but when it is remembered that the bitulithic surface weighs 250 pounds per square yard and the sheet asphalt 200 pounds and that an average of 2 pounds seal coat bitumen is used on the bitulithic and not specified in sheet asphalt, the total quantity is about the same in both cases.

The penetration of the bitumen is naturally dependent upon the climate, varying from 50 in the extremely hot arid climate of parts of Arizona to 100 in Northwestern Canada. The penetration can be safely made somewhat softer than that used in sand-mixture pavements on account of the interlocking of the mineral aggregates, thus relieving the bitumen of some of the strain of holding the particles of aggregate in position.

As ductility is a measure of the cementing strength of the bituminous cement, this is kept as high as is consistent with other characteristics of the bitumen and with the climatic conditions to be withstood. For instance, the most ductile bitumens are also the ones which change most in penetration with changes in temperature. On the other hand, less ductile bitumens while very stable in penetration with changes of temperature are lacking in cementing strength. Therefore the problem is to make the "blend" which will conserve to the highest practicable degree the all important factor of cementing strength and yet obtain as much stability of penetration as possible.

Temperature of Mixture.

In order to facilitate working on the street and insure compression, this is held as high as practicable and avoid injury to the bituminous cement, the exact temperature depending among other things upon the length of haul or rather upon the length of time the material is in the wagon or truck for the bitumen when spread in thin films on the mineral aggregate will harden more rapidly at any given temperature than it will at the same temperature when in a large body, as in the melting tanks at the plant. Ordinarily 250 deg F. at the street will make the mixture work properly unless weather is cold or a strong wind blowing when 275 or 300 deg. may be necessary.

Compression.

This is an extremely important feature. The roller should be of the usual 3-wheel type, rated at 10 tons, i. e., 22,400 pounds exclusive of water and coal, with 24-inch face on the rear wheels. The roller should be kept in operation continuously until the pavement is thoroly compressed. It is manifestly absurd to provide a mixture which is capable of being compacted to such a dense mass, unless it is actually so compacted on the street. A careless or lazy rollerman can spoil any mixture but the best rollerman can not make a good pavement with a poor mixture.

Other types of bituminous pavements will be considered in the next article.

Aid in writing this article has come from so many sources that individual acknowledgements are hardly possible.

BITULITHIC PAVEMENT IN MARLBORO STREET EAST OF MASSACHUSETTS AVENUE, LAID OVER OLD MACADAM IN 1914.

BRICK SEWERS

By J. F. Springer, New York City.

The author of this article has gathered together some brief descriptions of recent methods of using brick in sewer construction in some instances in combination with concrete, which will be of interest, and has added some illustrations showing standard simple construction by methods in use since brick sewer construction was begun, so that together he has quite well covered the construction of the sewer barrel itself under ordinary conditions.

BRICK has long been the standard material for sewer construction, especially where the diameter is larger than 2 to 2½ feet. If the inner surface of the sewer is left unlined it will be best perhaps to rate the roughness as greater than that of a properly finished concrete sewer. This consideration will naturally affect the carrying capacity. Brick construction will often be economical because of local conditions. The most important of such conditions will ordinarily be the cost of the brick themselves.

Standard Dimensions.

The standard brick will have the dimensions, 2¼x4x8¼. There will be variations from this even where the bricks all come from the same mold, since under-burned, medium-burned and overburned bricks disclose corresponding degrees of contraction. Generally, the more a brick is burned, the greater will be the shrinkage. The medium-burned are the better quality and will probably be the most uniform in size.

Attention has been directed to the importance, in laying, of apparently small differences in dimensions. A brick that is full 8¼ inches long, has a very considerable advantage over one 7½ inches long. When one longer brick is placed, there has been put in position 10 per cent more lining than when one shorter brick has been laid. Again, when a brick 2¼ inches thick has been placed, we have an advantage of 12½ per cent over a 2-inch brick. Taking the two dimensions in combination, the laying of an 8¼x2¼-inch brick has an advantage of 23¾ per cent over the laying of a 7½x2-inch brick, since the corresponding areas are $18\frac{9}{16}$ square inches and 15 square inches. The thickness of the mortar has not been included in the estimates. The width of the brick is a consideration which affects the thickness of the sewer wall. It is also important. A two-ring sewer of brick 4 inches wide will be, say 8½ inches thick in wall, while a 3½-inch brick will reduce the wall thickness, say to 7½ inches. The one sewer will have a wall thickness over 13 per cent greater than the other. It is well to be on the alert as to exact actual sizes of the brick being used.

Porosity of Sewer Brick.

The brick employed in sewer construction should have only a very moderate absorption capacity. An imperfectly burned brick may absorb one-third of its own volume of water in the space of 24 hours. This is entirely too porous. Brick burned very hard may absorb as little as 2 or 3 per cent. This brick is otherwise undesirable. We are not able to secure a brick that is non-absorptive; we must take an intermediate product and use a brick having an absorptive capacity between 10 and 20 per cent, by volume, in the space of 24 hours. It is understood that the specifications of the New York City authorities permit rejection if the absorption exceeds 16 per cent.

If one desires to carry out an absorption test, it is quite a simple matter. The first thing to do after securing fair, average samples, is to make sure we are starting with dry brick. We may put them in an oven for a considerable period, maintaining the temperature at, say 100 or 125 degrees, Fahrenheit. If there is any uncertainty as to whether the bricks are really dry, we may remove them and weight them collectively. We then replace them in the oven and after a time reweigh. If the weights are now the same as before, the bricks were dry when first removed and are dry now. The dry bricks are now placed in a tank whose walls are non-absorptive, and which is provided with a vertical gage glass equipped with a suitable scale. The bricks are left in water in the tank for, say 24 hours. The difference in the readings on the scale when the bricks were first submerged and now will show what volume of water has been absorbed. The result will be a little too large, perhaps, because of evaporation in the meantime. To check this procedure, we may carefully dry the surfaces of the bricks after the 24-hour period of submergence with the aid of blotting paper or other absorbent and then weigh them collectively. The increase in weight will indicate the amount of water absorbed.

Quality of Brick.

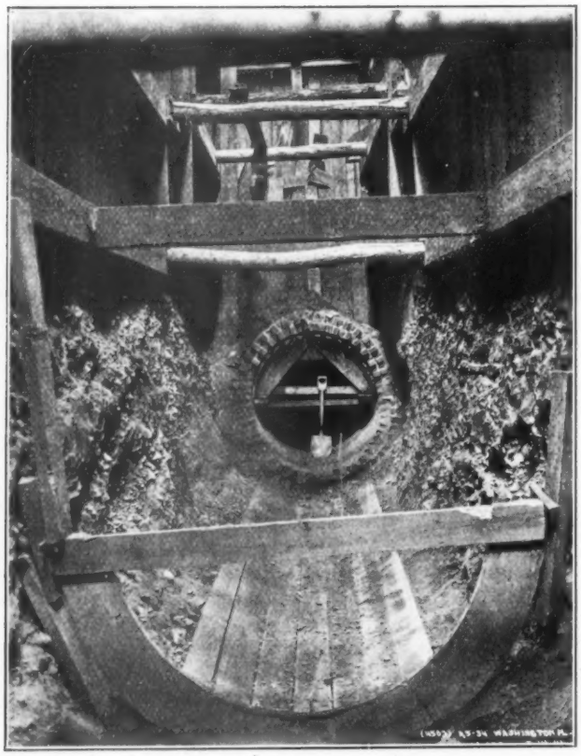
The texture of the brick is a further consideration. It should be uniform and rather dense. We may test roughly for a proper combination of both qualities—that is, for proper texture—by striking a sample brick sharply with a trowel, the brick being held loosely in the hand. If there is a clear ringing sound. the texture is probably good. Density may, of course, be tested by weighing, and uniformity of texture by ocular observation of fractures. The color indicates quality to some extent. A perfect brick from certain given materials will have its own peculiar color. Variations from this color are to be shunned where the ingredients are the same.

Speed of Laying.

The cost of laying brick in a sewer will naturally turn on the cost and expertness of labor; but it depends also on the location of the work at the moment. The brick of the inner ring will ordinarily cost more to lay than those immediately back of it. In the arch, however, this difference is lessened by the fact that the inner ring of the arch is laid upon a center of wood or other material. A good mason will place from three to six bricks per minute, if not delayed by irregularities in his supplies. Proper service will require perhaps 3 to 4 tenders to each mason. Naturally, special conditions will introduce wide variations.

Mortar for Brick Laying.

The mortar that goes into the brick sewer is very important. The sand should be clean. That is, it should not be mingled with clay and loam. The reason underlying this requirement is that the binding material in the mortar, the cement, cannot perfectly interpenetrate such materials. Consequently, wherever there is a bit of clay or loam, there is a spot where some particles are only weakly held together. If dirty sand only can be obtained the sewer contractor should provide for washing it clean. Another requirement is that the sand shall have sharp and angular edges—that is, should not be rounded. Whether angular grains are really better than rounded ones is perhaps open to some doubt. However, the sand should at least consist of various sizes of grains so proportioned in amounts, that when the mortar



CIRCULAR FIFTY-FOUR-INCH, TWO-RING, BRICK SEWER UNDER CONSTRUCTION. IN BACKGROUND END OF COMPLETED SECTION WITH ARCH FORM STILL IN PLACE. IN FOREGROUND TEMPLATE READY FOR LAYING BRICK COURSES OF INVERT TO LINE WITH PLANK CRADLE FOR BOTTOM COURSES. NOTE SHEETING AND BRACING ABOVE AND SOLID MATERIAL BELOW.

is made and hardened, we will get a very dense material. The proportion of cement should be generous. Upon it depends the strength of the resulting mortar. The formula 1:2 or 1:1½ will, if the sand is properly graded, produce a dense mortar reasonably impermeable to water.

The resultant mortar will measure but little more than the loose dry sand, notwithstanding the addition of cement and water. Thus, for a 1:2 mortar, if the cement is heavy (108 pounds per cubic foot), 2 cubic feet of sand will produce but 2.20 feet of plastic mortar. If the cement is light (95 pounds per cubic foot), the 2 cubic feet of sand will yield only 2.11 cubic feet of mortar. The cement and water more than fill up the voids. In poor mixtures where there is lack of cement, the resulting mortar may even be less in volume than the sand. That is, the cement and water seem unable to fill the voids in the loose sand, and instead may cause the grains of sand to come closer together, compacting the original volume of sand. In fact, when the cement is a little less than one-third the volume of the loose sand, the final mortar will have the same bulk as the sand originally had. We have a fairly good rough test of the quality of the mortar in consequence of the foregoing. If the volume of the final plastic mortar is distinctly greater than the volume of the loose dry sand, then we have a rich mixture.

Number of Bricks in the Arch Rings.

It will readily be understood that, if brick is continually placed back of brick in the arch, the radial layers of mortar will get thicker and thicker as ring of brick is added to ring. If there are quite a number of rings in the arch, this thickness of mortar will become undesirably great. To overcome this difficulty the arch may be divided into a number of short arcs. These may be bulit out to depths of two and three bricks, segments of two bricks alternating with those of three. Upon these segments others may be built out as if starting anew. The number of brick in the new segment will contain one more than the number in the old. This was the method employed in the construction of the Walworth Run sewer at Cleveland, Ohio. At the crown of the arch, the sewer was four or five bricks thick. The thickness of the arch increased to the springing lines. The interior was circular, the diameter being 10¼ feet. The inner arch brick were laid in Flemish bond in alternate headers and stretchers. The sewer varied in dimensions at different locations.

Standardizing Sewer Brick Laying.

Not long ago an attempt was made at St. Louis to standardize the laying of brick in sewer construction. The brick work involved totaled, as Mr. C. L. French in effect tells us, some 10,000 cubic yards, all but 6.6 per cent. of which made use of common brick. As 430 common brick went into a cubic yard, the test involved a total of over 4,000,000 brick.

The bricklayers were each able to lay, on the average, 11.05 cubic yards of brick work per day of eight hours. This means nearly 600 bricks per hour per man—a brick every 6 seconds or a trifle longer. This seems extraordinarily fast work for such a long job. The bricklayers were $9 men. Apparently a serious effort was made not to waste their time. This required that they should not have to wait for laborers. On the other hand, it was deemed just as expensive to have too few bricklayers on the spot.

It was found to be important to have the mortar just right all the time. It was mixed by machinery at a cost of less than $0.01 per cubic yard for power. From the machine, the mortar was dumped into barrows and these delivered, attention was given to "planning the work so that a certain number of bricklayers could be constantly employed," this resulting in keeping the best men. "The importance of this feature is nearly always underestimated by contractors. The difference between work done by a good man and an average man is at least 10 per cent, and where full time can be made, the very best men are obtainable." It would seem that no great effort was made to push the men; but "proper working room,

THREE-RING BRICK SEWER. INVERT COMPLETED IN FOREGROUND. ARCH FORM IN PLACE. NOTE METHOD OF BLOCKING UP ARCH FORMS. BLOCKS EASILY REMOVABLE FOR DROPPING THE FORM TO MAKE IT EASY TO MOVE FORWARD. NOTE STRENGTH OF SIDEWALLS NECESSARY TO CARRY WEIGHT FROM ABOVE.

sufficient materials in right place, and safe working conditions" appear to have been the prominent things kept in view. With reference to the safety item, it may be noted that brick baskets were employed instead of slings.

In spite of the high wage paid to the bricklayers, the average cost per cubic yard of common brick for materials and labor was $6.90.

It may be added, as a matter of practical interest, that the mortar formula followed on this work was 1:3. Such mortar, as we have substantially found already, would just about equal in volume the dry sand employed.

A Method of Moving the Arch Center.

The arch of a brick sewer is ordinarily laid on a wooden center. A rather novel method of handling such a center was employed in constructing a brick storm sewer at Cedar Rapids, Iowa. The sewer is something over a half mile long and divided into a five-foot and a six-foot section. The grade is 0.25 per cent at the upper end, but this drop is increased to 1 per cent for the final 1,000 feet.

The movable center was 14 feet in length and had seven semi-circular ribs, covered with lagging 2 by 4 inches in section. However, as well as one may gather, the semi-circle was not fully completed, the bottom 3 inches being omitted. This arrangement permitted the form to be dropped a trifle after the brickwork above it was all in place.

The form was mounted on wheels, two in front and one to the rear. A track was laid on the invert in the following manner: Cross-ties of 4 by 6-inch material were chamfered at the ends to fit the curvature of the invert and carried a track or roadway of 2 by 10-inch planks.

When the form is in place the wheels are wedged up to elevate the form. So, in removing, the blocks are withdrawn, whereupon the whels drop on the tracks and the whole form whereupon the wheels drop on the tracks and the whole form put in place on the track to cause the single rear wheel to rise and bring the crown of the wooden arch form at its rear end up to the level of the inner curve of the finished brick arch at its outer edge. Having the rear of the form in place, the forward wheels, two in number, would be blocked up to bring the front end of the form into exact position. In using this form, one hour or more was allowed to the newly finished brick arch before the form was moved on to the next position.

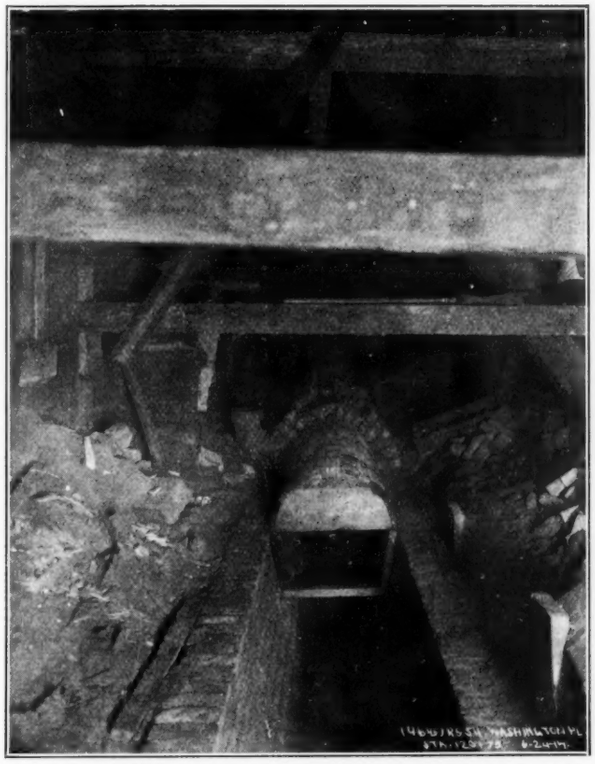
Vitrified paving blocks, square or nearly square in section, were employed on this work. Cement mortar was used to bind them together.

There were two rings, laid without brick bond between them. In the inner one, the longitudinal joints were in thickness about ¼ inch; in the outer ring about ½ inch. Cement mortar was spread over the surface of the invert and sides. This surfacing was smoothed until the maximum projections were not larger than ⅛ inch. In order to prevent the ground water from penetrating the arch, it was covered over on the exterior with a cement mortar made on the formula, 1:2.

There are now in use metal forms which are collapsible and removable in a manner somewhat similar to that above described. A photograph of a Blaw collapsible steel form shows the manner in which they are used.

Foundations for Brick Sewers.

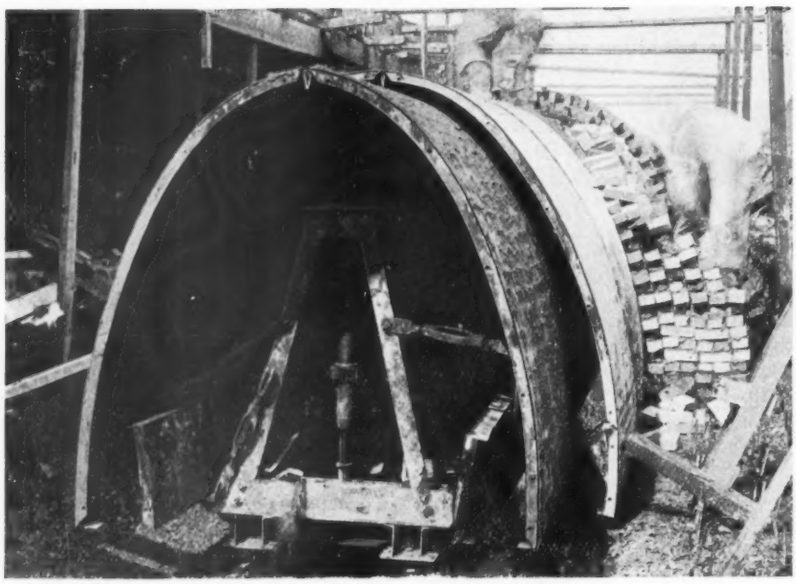
A brick sewer will at times require a foundation. The underlying soil may be unequal to the support of the bare sewer. In such cases one method of meeting the difficulty is to spread the under surface of the sewer and thus secure a broader footing. This may result in a heavy demand for material for the lower half of the sewer. It is not necessary, usually, that the added material be brick. If conditions favor its use, concrete is a very proper material. The brick-work may be continued all around, thus forming the lining of the lower half. The concrete used for foundation purposes will, naturally, be a rather lean mixture unless some special conditions require a rich material. The Walworth Run sewer, already referred to, is an example illustrative of a big wide base of concrete. The section of the bore is circular. Corresponding to a 10¼-foot inside diameter, the base has a width of a little over 20 feet. The underlying blue clay was found to be plastic and to have a supporting power of only 2 tons per square foot. The minimum thickness of the concrete beneath the two rings of the invert was made 1½ feet. But the concrete itself was carried on a wooden cradle consisting of oak sleepers 3 by 12 inches in section, and oak planking 3 inches thick. The sleepers were placed at intervals of not less than 4 feet, center. This sewer had various sizes. Corresponding to them were various widths of the concrete foundation up to 30¾ feet for the 16½-foot sewer size. Roughly, the width of the base was double the bore for all sizes.



TWO-RING EGG-SHAPED SEWER. INVERT COMPLETED. ARCH-FORM IN PLACE READY FOR WORK. A PIPE SEWER CONNECTION SET AT SPRINGING LINE READY FOR BRICKING INTO THE ARCH. NOTE METHOD OF SUPPORTING ARCH FORM ON SIDEWALLS OF INVERT.

Some years ago Philadelphia built some egg-shaped sewers. Some of them were provided with a concrete foundation or cradle. The base was greatly widened out and was carried, some of it on piles whose heads penetrated slightly into the base, and some of it on a timber flooring carried by piles. Where the piles were in direct contact with the concrete, reinforcing bars were imbedded in the concrete. These were equivalent to ¾-inch square bars and were laid transversely at intervals of 1 foot, center to center.

Another Philadelphia sewer is that which derives its name from Mill Creek. The section is semi-eliptical or parabolic. The arch is of brick and the invert of stone blocks, the arch and invert being carried by a broad base or foundation of rubble masonry.



NINE-FOOT TELESCOPIC SEWER FORM, HORSE-SHOE DESIGN, BLAW TYPE, USED BY READY AND CALLAGHAN COAL CO., CONTRACTORS, ON CHICAGO CONTRACT.

Cross-Sections of Brick Sewers.

A Lancaster, Pennsylvania, type of construction has a four-ring circular arch of brick with a slightly curved invert of one ring. At the center of the invert a 24-inch semi-circular gutter or channel is provided to take the dry weather flow. The narrow channel, well filled, will have a better flow than a wide channel with the same volume spread thinly over the surface.

There are very numerous sections which engineers have used in sewer construction. Brick lends itself very well to a great diversity. The circular sewer is undoubtedly strong and provides a good flow when the liquid contents are in only moderate amount. The egg-shaped form is doubtless an improvement in giving facility of liquid movement when small quantities of dry-weather flow of sewage are to be disposed of. Prof. R. DeL. French concludes that when a circular sewer is filled no more than 35 per cent of its height, the corresponding egg-shaped sewer is superior.

The capacity of a sewer naturally turns on the velocity of flow. One of the variables on which the velocity depends is the smoothness of the inner surface. In this respect brick is to be rated as somewhat inferior to concrete, it being common to grant concrete from one to three points advantage over brick. Metcalf and Eddy in "American Sewerage Practice," recommend for the values of the factor representing the roughness of the channel in Kutter's formula for the flow in sewers, 0.012 and 0.013 when concrete is the material, and 0.014 and 0.015 and even larger numbers when brick is the material, the smaller factor giving the larger flow.

Repairs to Brick Sewers.

As a brick sewer wears, the roughness increases, the value of the factor naturally increases and the velocity consequently decreases. The mortar is eroded out of the joints, particularly in the invert. It may disintegrate and drop out of the arch. As to accumulations on the surface, brick is not the only material affected by them. It is quite important, in view of the foregoing, to know if it really be possible to restore the joints and to give the whole surface a cement or a cement mortar finish. The breakdown of the joints means deterioration of the sewer itself in addition to the loss of capacity thru the increased roughness. Cement mortar will strengthen the sewer walls and give them smoothness if applied as lining of the eroded brick so that it will be sure to adhere.

There are two methods of applying cement or cement mortar that call for attention. By the one method, the material is mixed by the aid of steam and then driven thru a transmission line and out of a nozzle in a jet. Superheated steam is used to produce the jet and project the material. The surface to be coated is bombarded by the grout. Adhesion is understood to be promoted by this action, and also the density of the coating. The crevices will be filled up and a surface layer put on. The coating may be built up layer by layer to any reasonable thickness. The sewer, whether new or old, may be treated. It will be necessary in the case of old constructions to remove slime and other accretions. The impact of cement mortar will ordinarily result at first in the adhesion of the cement alone, the sand rebounding. But, after a little, the cement coating gets thick enough to hold the sand. There will thus undoubtedly be a thin layer of pure cement against the brick surface, and on top of this the layers of mortar. The steam method may also be used for lining with concrete. The material falling to the ground may be recovered and used again.

There is an alternative method which operates also by a jet, only in this case the driving power is furnished by compressed air. This method may be utilized to coat with cement or with cement mortar. We have results similar to those described.

The steam method is particularly attractive, because no additonal special apparatus is required beyond the machine which mixes and then atomizes the material and the transmission hose or pipe. Steam is required, superheated steam, but that is a very easy requirement to fill. It is not necessary to have the plant close to the point of use. In fact, it may be located upon the surface and at some considerable distance, if need be. A rubber hose may be used for transmision, particularly if rounded pebbles be employed as aggregate in the concrete. The superheating of the steam is necessary or advisable for several reasons. In the first place, steam has driving power when it is steam and not when it has condensed to water. Consequently, thruout the pipe line, it must be hot enough to avoid danger of condensation. Some of the heat goes into the pipe itself. Indeed, a preliminary to operation is the sending thru the line of a gust of steam to clear out the pipe and heat it up somewhat. When operating, steam should be pretty hot as it emerges at the nozzle. Otherwise, it may be expected to condense betwen the nozzle and the surface which is being coated, thus creating a cloud of vapor and obscuring the vision of the man handling the nozzle. Eighty pounds pressure will be sufficient for many usual cases.

The compressed air system which has been referred to as suitable for cement and cement mortar uses a portable apparatus which discharges dry material into a discharge hose, water being added subsequently to the material leaving the machine proper. Whether a considerable length of hose is practicable, I do not know.

There is still another system, referred to at the close of my article on "Methods of Concrete Sewer Construction," in MUNICIPAL ENGINEERING for August, 1916. The procedure

employs compressed air and is adapted to concrete as well as to grout. The materials, including the water, are all more or less mingled prior to leaving the machine. This system may be advantageously used where large amounts of material are to be placed in position.

To sum up: If we want to put in a very heavy lining of concrete, the last mentioned system is especially suitable. If we want to fill in small cracks, and put on a thin layer of cement, cement mortar, or pebble concrete, the steam system is a good one; or if we want to fix up cracks and then put on a thin coat of cement or cement mortar, the system is suitable which drives dry material from the machine by compressed air, adding water as a final contribution.

At St. Louis, those in charge of the sewer work investigated the suitability of one of the systems adapted for putting on thin layers of cement or cement mortar, with a view to use on large old sewers of brick and ashlar. The cleaning and other preparation of the surfaces was one of the problems. The wire brush was the first thing tried but was abandoned. The sand blast was also experimented with, but had to be discarded because of the lack of sufficient compressed air to operate properly. This is not to be regarded as in any way condemning the sand blast. They didn't have enough air. The procedure actually employed was "to pick and scrape the mortar out of the joints with a tuck-pointer's tool. Many old sewers, however, are too thickly covered with foreign growths to be susceptible to any scarifying method except the sand blast." Whether the trowel should be used in smoothing off the coating depends upon the advisability, in any particular case, of spending the small sum necessary. If the utmost capacity of the sewer is needed, troweling will probably be advisable. It is thought that the advantage of troweling, over leaving the coat as deposited by the machine used, amounts to about 0.002 in the factor for roughness in Kutter's Formula. That is not to be understood as necessarily meaning that the values 0.012 and 0.031 for concrete are to be cut down to 0.010 and 0.011. Hardly. Rather should we say that only after troweling are the figures 0.012 and 0.013 really justified. Under the conditions in St. Louis, this decrease from 0.015 to 0.013 appears to result in an increase in the velocity, and therefore of the capacity on this account, amounting to about 9 per cent. Increase in the area of cross-section of the sewer due to cleaning would increase the capacity also. No increase in the fall in the sewer would result probably, so there would be no change in discharge on that account. The change in the factor of roughness of 0.002 is a notable one, although it may not always mean a 9 per cent change in the velocity. In the experimental work at St. Louis, a sharp-cornered metal float was used. It was proposed to use a round-cornered wooden float in subsequent work.

Mr. L. Chivvis, the engineer reporting the St. Louis investigation, appears to believe that it is possible to repair and renew to proper usefulness many old and decaying brick sewers, sewers constructed, it may be, before the advent of portland cement. He refers to old St. Louis sewers in which the damage is limited to the joints between the bricks, stating that the erosion has extended to an extreme of several inches of depth in the invert and to a minimum of next to nothing in the arch.

It would appear then, since there must be old brick sewers all over the country, that it is a matter of very considerable importance, if it is really possible not only to restore and improve capacity, but to prolong the life of such structures.

If the sewer is nearing collapse and in consequence it becomes necessary to put in a concrete lining of considerable thickness, we shall have to remember that the result will be a smaller sewer.

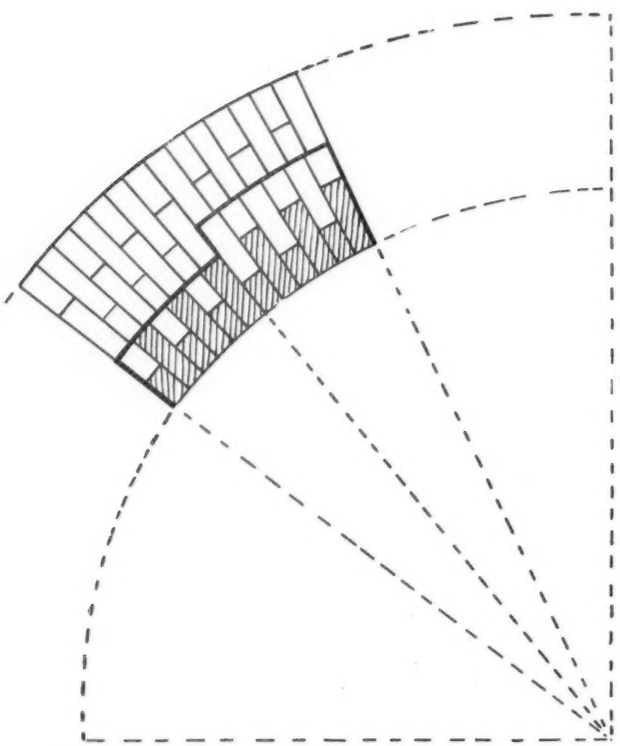
Waterproofing a Sewer.

Before leaving the consideration of these mechanical procedures for applying cement mixtures, a word may well be said as to the rather evident applicability of two of them to the purpose of adding an outside roofing coating to brick sewers. Such a coating is added not so much to increase the strength of the arch, altho it probably does do that to a measurable degree, as to prevent the filtering in of ground water. A comparatively thin coat will be all that will ordinarily be added for this purpose. If used at all, the mixture should be either a pure cement grout or a rich cement mortar. A dense layer will probably satisfy expectations, if no more is expected than a reduction of the permeability. If, however, we wish to go further and make the coating really waterproof, that is, non-absorbent, we may use the method recently developed by the United States Government. This method adds oil to the cement mixture, a certain simple technique being followed in making the addition. It is not enough to use any convenient mineral oil. On the contrary, the oil should conform to certain specifications. A letter directed to Superintendent of Documents, Washington, D. C., and accompanied by ten cents will pay the charge for a post-free copy of Bulletin No. 230 of the United States Department of Agriculture, entitled, "Oil Mixed Portland Cement Concrete." This document will supply detailed information on the use of oil with concrete.

Brick Inverts in Concrete Sewers.

It is of interest to note that brick has been used for the purpose of lining the invert of a concrete sewer. The object in view was to provide a better wearing surface. An example in this connection is afforded by sewer work lately carried out at Toronto, Canada. In one section (No. 4) of the main Garrison Creek storm overflow sewer, three sizes of circular sewer

STANDARD HALF-ROUND SEWER FORMS USED ON 42-INCH TO 72-INCH BRICK SEWERS ON ATLANTA, GA., CONTRACTS BY C. W. LANE & CO. BLAW TYPE.



METHOD OF JOINTING BRICK MASONRY IN WALWORTH RUN SEWER, CLEVELAND, OHIO.

were constructed, 8.00, 9.50 and 9.25 feet diameters. The influence of a steep grade on capacity is shown by the fact that the smallest size of sewer carries the full capacity of either of the others. Thus, the 9½-foot sewer with a grade of 1 in 300 has a capacity no greater than the 8-foot sewer with a grade of 1 in 108. The object in view in varying the grade and size was to avoid a stratum or strata of sand, disclosed by preliminary borings. Even so, the sand reached, at some points, a level just above sub-grade and at others a level up to the springing line.

Part of this portion of the sewer was constructed in open cut and part in tunnel, the total length of 3,425 feet being nearly equally divided between the two. A square concrete base was given to the sewer where it was in open cut. This was to secure the structure against settlement in the sand. In the tunnel divisions, sand was in evidence part of the way, so that a square base was here employed. But for nearly 1,100 linear feet of the tunnel, a circular base was used, the sand being absent. The concrete was made in accordance with the formula 1:3:5.

The radial thickness of the masonry was, in general, the same in the arch as in the invert, with the increases due to the square base where it was employed. The arch concrete was made 18 inches thick; the invert concrete 13⅛ inches, thus providing 4½ inches radially for the brick lining. This lining was constructed of hard red shale brick. Steel forms were used for part of the work. These took care of the invert semi-circle at one operation and of the arch semi-circle at another. It was necessary, naturally, to use a larger diameter for the invert in order to provide room for the brick lining. In certain work in open cut a 60-foot section of form would be set in the invert and the concrete poured. The turnbuckles would be released after the concrete had set sufficiently, and the steel section drawn ahead to the next location. The brick lining was now put in place. In order to provide for the support and for the moving ahead of the arch form on small wheels a wooden track was provided, consisting of 2-inch planking supported by cross pieces, 6 by 6 inches in section, which rested on the brickwork.

It will be noted that here in the open cut construction the brick lining of the invert was in place before the arch concrete was poured. In the tunnel construction, on the other hand, the brick were placed after all concrete was in position.

In excavating the tunnel, the upper half was first removed from an entire section, the lower half, the bench, being left in place. As the excavation of the upper half went on, the arch concrete was quickly put in place. That is to say, a section of 12 to 15 feet was excavated, when the lining would be put in. The next section would then be excavated and so on. The bench continually provided support for the arch form and for the track on which ran the muck cars.

When the entire section of tunnel had received its arch lining of 18 inches of concrete, the bench was removed in a series of sections of 12 or 15 feet length, these sections alternating with similar sections of bench left undisturbed. As bench support for the track was taken away, trestlework was substituted. The concrete for the invert was then put in, a space of 1 foot being left, between invert and arch. The concrete was now allowed to set for 48 hours or longer, when brick underpinning was put in the open space. The interval of time was allowed for possible shrinkage of the invert concrete.

After all the excavated sections of the invert had been thus concreted and the underpinning set, the unexcavated sections were dealt with, the same general procedure being followed. In this way the concrete arch was continually supported by the invert.

After all the concreting had been completed, the brick lining was put in place on the 13½-inch concrete invert. It is understood that the foregoing method of excavation had its first Canadian trial in this work at Toronto.

Cost of Brick Sewers.

Naturally, the cost of brickwork in sewers varies with numerous items, cost of labor, cost of material, special conditions, etc. In general, however, the brickwork may be expected to cost from $10 to $14 per cubic yard, or, say, $20 to $28 per thousand of bricks. This rough estimate includes labor, materials, tools, supervision. Other things in general being the same, a small diameter sewer will cost more than one of large diameter per thousand of bricks laid.

It has not unreasonably been suggested, in effect, that one mason will lay his thousand of bricks in 3.2 hours, that he will need labor help to the amount of 9.6 man-hours, that 2 barrels of cement will be consumed, that 0.56 cubic yards of sand will be used and that centering will cost 0.10. By means of these data one may calculate from local prices for labor and material the fundamental costs for labor and materials. Add to the total the cost of one thousand of bricks. We now have the total for labor and material. Finally add 15 per cent of this total to cover expense of supervision, lumber and tools. We will then have a pretty fair average estimate for the cost of 1,000 brick in place. To get the cost of one cubic yard in place, divide by 2.

The Public Service Commission for the First District, New York, has had important sewer construction in New York City under its supervision. Photographs of some of this work are shown in the present article.

WATER PROOF PAVEMENTS

Some papers before the Engineering Section of the American Association for the Advancement of Science show the necessity of water proofing pavements of modern design and thus get back to the first principles on which John Macadam based the design of the broken stone road which bears his name.

One of these papers is by Prof. Maurice B. Greenough, consulting engineer of the National Paving Brick Manufacturers' Association, on the real sources of troubles with brick pavements, and he finds that most of them are with water in one way or another.

Another is by C. J. Morrison, of Meyer, Morrison & Co., New York, and discusses directly the necessity for adequate methods of water proofing in road construction.

A third paper by A. T. Goldbeck, engineer of tests in the U. S. Office of Public Roads, considers, among many other things, the effect of water in expanding and cracking concrete, as well as its effect on foundations.

Still a fourth paper, by H. H. Schmidt, chief engineer of highways, Brooklyn, N. Y., while not discussing the dangers of water in pavements, develops a filler for granite block pavements which makes the pavement water-proof, thus meeting the second of his twelve requirements of the perfect filler.

And a fifth paper, by Philip P. Sharples, of New York, details the experiments that have been made in various cities with various materials and mixtures for making mastic (sand and bitumen) joints and the reasons for the successes and the failures observed.

From these papers this article has been prepared to show the methods used in the most modern pavements of meeting this ancient problem in road building, which has always been the most important one and will be as long as rain falls and water runs over or under or thru the roads or their foundations.

LONG ago the road pavement and the wheel were recognized as two parts of the same machine for the application of tractive power in the transmission of weight from one place to another. The two parts of the machine should be designed together and not each independently, as has heretofore been the tendency; tho this tendency is becoming less pronounced each year.

One prominent defect in the design and construction of the pavement half of the machine has been lack of consideration of the weight of the traffic to be borne and consequent lack of attention to the possibilities of deformation of the pavement on account of the weight being greater than the foundation could carry or the surface being too soft to carry the weight, on the kind of wheels used, without displacement or disintegration.

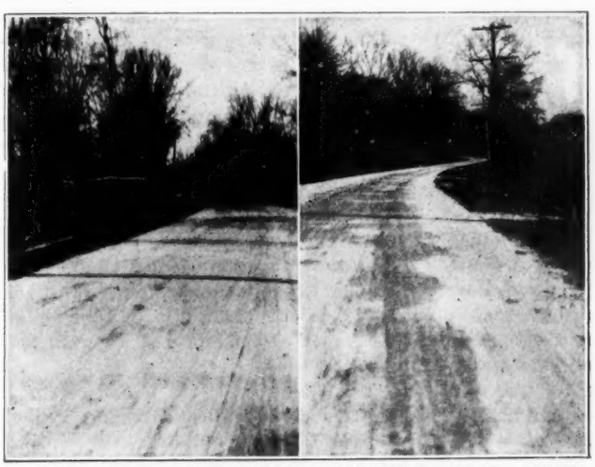
Neglecting the other important factors in the problem, this discussion covers only the effects of water on foundation and pavement and the methods of preventing or neutralizing these effects.

The first effect is that of undermining, the material below the pavement or in it being actually removed by the flow of water. Drainage, under or around the road or both, is so evidently the cure for this that it needs no further consideration except, in the design of the particular road, to select the best methods of removing or preventing the approach of water to the road on or under the surface.

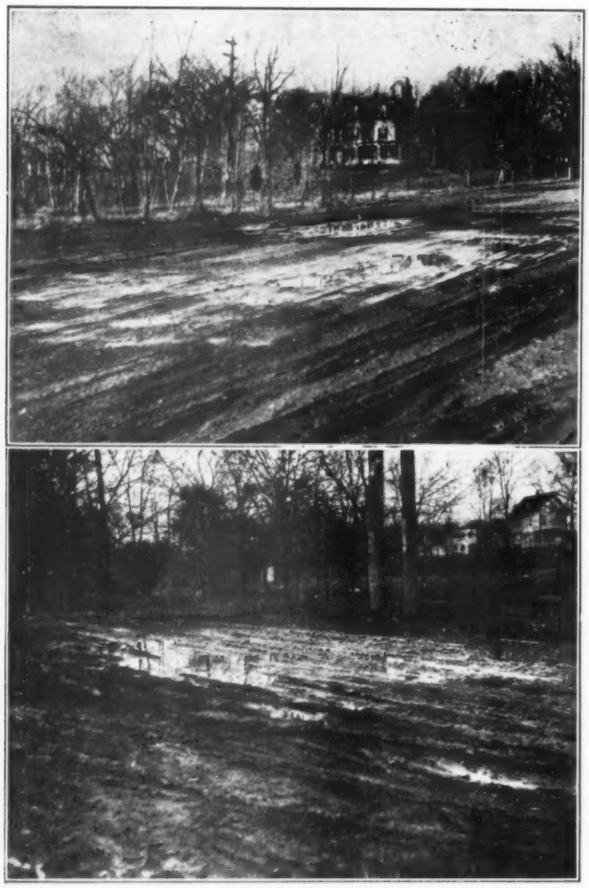
The water falling on the road itself or draining from one part of it to another, thru ruts or otherwise, if it can soak into the road, will loosen up the soil, especially when it freezes, upheaves and disintegrates the road or sub-grade, making it more susceptible to displacement by water flowing thru or against the road. It also softens up many kinds of pavements, and practically all kinds of material commonly found in sub-grades, so that they are not so well able to carry the weights put upon them. Thus roads which are properly designed for use in good weather may go to pieces very promptly after a spell of bad weather or an exceptional storm and flood. This is perhaps the most common mistake in the design and construction of roads and is certainly responsible for more failures of roads during and after their first or second winters than any other factor.

On level ground, drains and ditches should be used to take the water out of the sub-soil and carry it to ditches, drains or sewers which will remove it entirely from the vicinity of the road. The road or pavement itself can then be built on top of the drained surface or on a fill above it. The surface drainage is thus taken care of, provided the slope of the cross section is sufficient and the surface material will not be displaced by the traffic, forming ruts or waves or hollows.

That these apparently fundamental principles of road building on level ground are often violated is shown by the photographs of roads in Little Falls and Bloomfield, N. J., where they are all of them violated in roads of comparative recent



CONCRETE ROAD NEAR PLAINFILD, N. J., WITH SOFT ASPHALT TOP. BADLY DRAINED ROAD BED. RUTTED SURFACE.



ABOVE: MAIN ROAD IN LITTLE FALLS, N. J., CLOSE TO A RIVER AND ABOVE IT SO THAT THORO DRAINAGE IS EASY AND CHEAP.

BELOW: BROAD STREET, BLOOMFIELD, N. J., NEAR THE BUSINESS CENTER WITHOUT DRAINAGE, TWENTY-FOUR HOURS AFTER RAIN.

construction in populous and well-to-do villages on important local main roads which are also thru lines of travel.

A pair of photographs of a concrete road with soft asphalt surface, near Plainfield, N. J., show a road which is not properly protected from flowing water, nor adequately drained. This road also illustrates the effect of the choice of too soft a material for the top surface. The ruts in the soft bituminous surface are clearly seen in the photographs. They will soon be cut down to the concrete and the water falling on the level surface will stand in these ruts and soak into the more or less porous concrete, where it will produce the same effects in some degree that water always produces in a pavement, especially in frosty weather. C. J. Morrison, the author of the paper from which these data are taken, predicts that this road, tho new, will not survive its second winter and points to sections of the concrete broken off along the edges.

The photograph of the Morristown-Mendham road shows how the road builder may go out of his way to ruin his road. In the foreground is the foot of the slope of a cut in a side hill, the water from which could have been drained to the foot of the slope, only a few feet away, but it had been standing on and alongside the improved road surface for nine days when the picture was taken.

The opposite side of the road is on a fill, but instead of grading so as to lead water off the road, an embankment actually keeps the water standing on the road.

The same fault can be found with the road in the fill farther back in the picture, and the whole road is ruined by the water which should have been kept off, but which seems to have been kept on by the exercise of considerable ingenuity and hard work.

The photograph of Pompton Pike shows a road which is in good condition because it is well drained naturally, has natural protection from water, and a land surface of sufficient width. In this case the natural drainage has not been interfered with as in the road just criticised so seriously.

The fourth of the drawings shows complete provision for drainage of roads in cuts, to remove water from sub-soil and to keep surface water off the road. Now that loads on roads are becoming so heavy, and the necessity for solidity of foundation is becoming so much more pronounced, such provision as this, modified according to the special circumstances in each individual cut, is becoming each day more economical, tho the cost is still heavy. The photograph of the road near Englewood, N. J., shows the effects of lack of drainage of sub-soil and surface water and lack of waterproofing of the road causing soft spots which develop the numerous hollows and holes seen in the picture. Ridges upheaved by frosts in February had not been repaired in December when the photograph was taken.

Ever since modern road building for wheel traffic began, say with John Macadam, the importance of drainage has been recognized. The value of the waterproof surface has also been seen, but motor truck traffic with its heavy loads and greater speeds has emphasized the waterproof surface as of prime importance to a road, not second event to the material of which the road is made.

In Prof. Greenough's discussion of the sources of troubles with brick pavements, he attributes at least part of the longitudinal cracks which occur in such pavements, particularly in county highways, to the presence of water in or under the pavements. These cracks are most commonly found in region of wet and heavy clay soil and extreme ranges of temperature, and they are a minimum in number in sandy or gravelly soils of easy natural drainage. The cracking of the pavement may be due to heaving by the freezing of the wet sub-soil. Again, water seeping downward about the curbs will naturally work under the outer edges of the pavement and soften a portion of the sub-grade. The loss in supporting power thus induced may be enough to allow the pavement to drop at the sides and open longitudinal cracks.

When brick pavements are opened the sand cushions are almost always found to be wet. If such a wet cusnion should

MORRISTOWN.—MENDHAM ROAD, WEST OF MORRISTOWN, N. J. EFFORT SEEMS TO HAVE BEEN EXERTED HERE TO KEEP WATER ON THE ROAD RATHER THAN KEEP IT OFF, TO THE RUIN OF THE ROAD.

freeze, the expansion would doubtless act upward and might cause the cracks in the brick surface which are sometimes observed not accompanied by corresponding cracks in the concrete base.

This class of defects again emphasizes the necessity of thoro drainage of the sub-soil and thoro waterproofing of the surface in such way that it will continue to be water proof. It is further necessary to drain the gutters thoroly, so that water will not stand in them and thus have greater opportunity to find its way thru very small cracks or joints. The monolithic type of brick pavement does away with the sand cushion, but is still subject to disturbance of the sub-grade on account of the action of water and frost, unless the drainage is perfect, naturally or by construction.

A. T. Goldbeck, engineer of tests in the United States Office of Public Roads and Rural Engineering, in his paper on the causes of cracks in cement concrete pavements, goes into the theory of the action of water on concrete, checking up by reference to actual operations and draws some conclusions which are directly applicable to the question of making waterproof the wearing surfaces of roads.

In a completed concrete road or street, well cured and hardened, increase in temperature and absorption of moisture both produce expansion in the concrete, while decrease in temperature and drying out of the concrete induce contraction. This is demonstrated by data given in the paper which were derived from exact observations taken upon various sections of first-class concrete road. The two causes for expansion may act together or they may act in opposite directions so that it might even be possible that the expansion in a given length might be the sum of the two effects and at another time it might be zero. In figures, the shrinkage due to drying out the wet concrete may amount to 0.0004 inch per inch of length. A decrease in temperature of 100 deg. F., at the same time would give an additional shrinkage of 0.00055 inch, or a total shrinkage of very nearly 0.001 inch for each inch of length. If the change in temperature were an increase of 100 deg. rather than a decrease, than the contraction would be the difference between the two, or only 0.00015 inch per inch of length.

The larger amount of contraction may produce cracks, while the smaller amount probably will not in well cured concrete. In concrete which is in process of curing, cracks are almost sure to occur with even the smaller amount of contraction named.

Another fruitful cause of cracks in concrete pavements is unequal bearing of the concrete slabs on the sub-base. This

ROADWAY IN CUT NEAR ENGLEWOOD, N. J. WATER NOT KEPT OUT OR OFF. NOT WATERPROOFED. SOFTENED SPOTS WEAR INTO HOLES. RIDGES UPHEAVED BY FROST NOT REPAIRED.

POMPTON PIKE, ESSEX CO., N. J. WELL DRAINED, HARD SURFACE, GOOD CONDITION, MINIMUM MAINTENANCE COST.

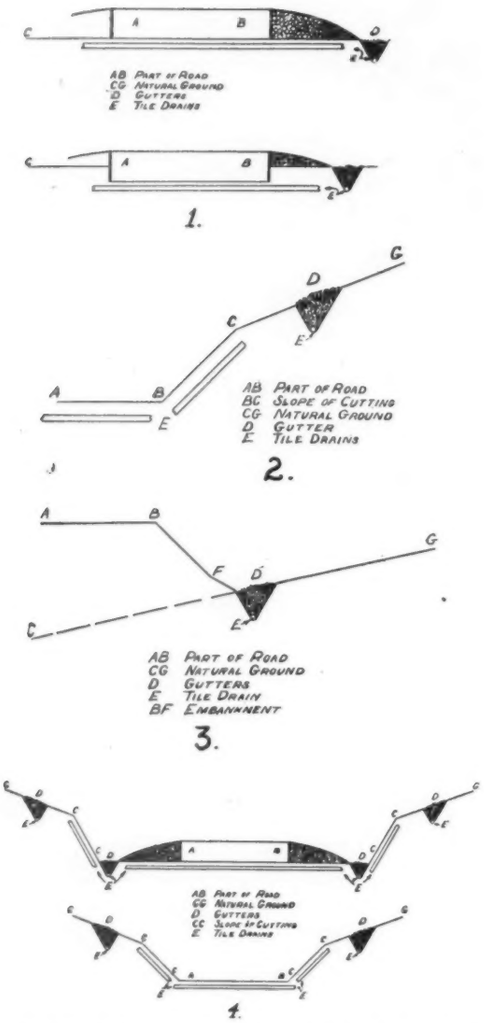
arises from inequalities in the surface of the sub-base. Neglecting other sources of inequalities, the softening of the sub-base in spots from the spots from the action of water, or the expansion of these spots thru freezing of the water, will transfer the weight of the slab and of the weight carried by the slab to these harder or upward projecting spots and the portions of the slab between are unsupported or but partially supported. Thus, freezing of the sub-base near the edges of the slab would make of it a beam, supported at the two ends; whereas, softening of the sub-base under the edges of the pavement, thru soaking it with water, or washing it out by the action of water, would make of the slab a beam supported in the middle and unsupported at the ends.

Mr. Goldbeck says that "the raising of the sub-base in spots need not be more than 0.2 inch to cause cracking, and the expansive effect of the frost and the swelling and shrinkage effect of moisture on the sub-base may be considerably more than this." He has some experiments in progress to show the effect of freezing and moisture on the vertical movement of the road.

Weight of traffic of course adds strains to those caused by these changes on the sub-base and their passage may be sufficient to cause cracks which would not form from either cause alone. This action of loads is exaggerated if the heavy weight travels rapidly on tires which are not continuous. They may cause longitudinal or transverse or diagonal cracks, according to the variations in location of the supporting spots. Corners and edges of slabs may be broken off by heavily loaded wheels running close to them.

Keeping the sub-base dry and making the concrete waterproof are the evident preventives of the actions of moisture described. Fearing that these things can not be done properly Mr. Goldbeck's final recommendation is to "design the slab as to thickness to carry the loads it is supposed to carry, irrespective of whether the sub-base offers uniform bearing, or not.

In the paper by H. H. Schmidt, Chief Engineer of the Brooklyn Bureau of Highways, on joint fillers for granite block pavements, he puts the water proof quality second in the list of twelve requirements of the perfect filler. He does not give the reasons for giving it this prominent place, but he shows what is the effect of modern heavy traffic on granite



1. CROSS-SECTION OF ROADS ON LEVEL GROUND, ONE ALTOGETHER ABOVE THE GENERAL SURFACE AND THE OTHER PARTLY BELOW IT.

2. CROSS-SECTION SHOWING PROVISIONS FOR DRAINAGE OF ROAD ON SIDE HILL, INTERCEPTING SURFACE WATER AND DRAWING OFF SUB-SOIL WATER.

3. CROSS-SECTION OF UPPER SIDE OF ROAD ON FILL SHOWING METHOD OF DRAINING AWAY WATER COMING DOWN HILL TO THE ROAD.

4. CROSS-SECTIONS OF ROADS IN CUTS SHOWING METHODS OF TAKING AND KEEPING WATER OUT. UPPER DRAWING SHOWS ROAD METAL IN PLACE; LOWER SHOWS EXCAVATION TO SUB-GRADE.

block streets and thus demonstrates the necessity for a smooth pavement with sufficient base and with sufficient strength of base and surface to withstand the traffic.

It may perhaps be assumed that granite blocks properly made and laid and of the best and most uniform stone, produce the most durable form of pavement under the heavy modern truck and trailer traffic. But granite streets have failed under a severe test by a large amount of the heaviest class of such traffic.

Applying the reasoning developed in the above abstracts from the other three papers, it may be shown that the reasons for the destruction of these pavements are in large part to be found in defective drainage of foundations and non-waterproof surfaces which let water into the sand cushion and caused inequalities in solidity of base and cushion respectively. These inequalities produced like inequalities in the surface of the granite block street, and the heavy traffic on hard tires moving rapidly, subjected to very heavy blows the corners of blocks caused to project by the unequal settlements of blocks. Again blocks driven down or softer than adjoining blocks, so that they wear down faster, produce low spots which again subject themselves and the corners of neighboring blocks to the heavy blows, which rapidly wear the small low spots into large deep holes. Proper waterproofing of pavement joints and proper protection from water of the sub-base will greatly improve the granite block pavement and give it longer life even under the grueling iron-tired trailer traffic.

The paper by Mr. Sharples presents the material for the application of the same reasoning to other block pavements, and definitely states the object of the bituminous fillers to be the waterproofing of street pavements of the block type.

Mr. Sharples's history shows that bituminous mortars for fillers in block pavements have been used in the United States since 1913. These fillers consist of mixtures of coal tar pitch and sand, or asphalt and sand. Specifications for both kinds were adopted at the 1916 meeting of the American Society of Municipal Improvements.

These bituminous mortars are particularly well adapted for use in filling the joints of stone block, brick, lug wood block, and Durax pavements. Observation shows that the asphalt-sand mastic does not fill the joints as well as the pitch-sand mortar, owing to the higher melting point of the former and its lower adhesive value.

Those bituminous mortar fillers that have given trouble to date have done so because not sufficient sand was originally mixed with the bitumen. A fine sand gives much better results than a coarse sand, and more of it can be introduced in the mastic. By properly heating and applying, a mastic with equal parts, by volume, of sand and bitumen can be forced into the joints of block pavements. For special conditions, special grades of bitumens must be used. Hand mixing is cheaper than machine mixing, and as good. The pouring method should be entirely dispensed with and the flushing and squeegeeing method substituted.

While but one of these papers takes up waterproofing as its principal theme, the discussions they give of this detail demonstrate its importance, especially under the traffic developments of the last four or five years.

Better materials than those we are now using for pavements will be hard to find. We must build our streets and roads to suit the traffic which develops, within reasonable limits of relative economy of hauling heavy loads. We admit defects in construction. Consequently we must improve our methods of construction. The unanimity of these papers by experts in pavements in emphasizing the value of waterproofing base and surface by removing water and keeping it out of base and of pavement proper, demonstrates its importance. Improvement of pavements in this regard will at this time produce better results than in any other one line of possible progress.

WORKERS IN THE FIELD

Repairing Pavement Cuts in Ottawa

THE EDITOR OF MUNICIPAL ENGINEERING:

Sir—During the past three years considerable attention has been given to the method of making repairs to pavements in Ottawa, where cuts have been made.

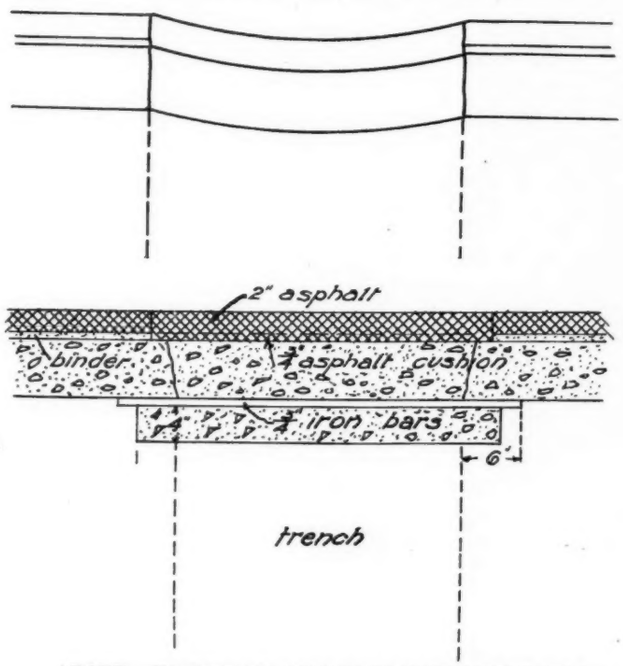
The repairs up to three years ago were done in a haphazard manner, the general result being the gradual settling of the packed-in earth, the concrete, of course, going with it, as shown in Fig. 1.

The present method of repairing cuts in pavements is shown by Fig 2. The trench is first of all well packed by means of a tamping machine. Then excavation is made to a depth of 4 inches below the old concrete, the sides of the old concrete being then slightly bevelled as shown. Square iron, three-quarter bars are then placed directly below the old concrete at 12-inch centers and the new concrete is afterwards placed and packed. The concrete is allowed to set for three days, then an asphalt cushion is pounded down and the asphalt wearing surface 2 inches thick is laid and compressed by an 8-ton roller. Great care is taken to secure a proper union between the old and new wearing surfaces. The edges are evenly cut away and cleaned up before the new top is put down. The practice of painting the edges with hot asphalt cement has been done away with as, if too much asphalt-cement be used, that portion of the pavement will be too rich in bitumen and will consequently be much softer than the rest. Smoothing irons are used to even up the joints, care being taken to see that they are not too hot, else they will burn the mixture.

In Ottawa a "Pavement Cut Book" is kept, where permits are given for the cutting of pavements. Thus, when a pavement is opened for the installing of gas, water or sewer, a record is available, and the cut is fixed up immediately the underground work is completed, thereby eliminating any fear of deterioration of the asphalt around the cut to any great extent.

The method of repairing the pavement cuts mentioned above costs a little more than formerly but this is more than offset by the good condition of the city streets.

L. MCLAREN HUNTER,
City Engineer's Department, Ottawa, Can.



ABOVE: EFFECT OF ORDINARY METHOD OF FILLING TRENCH AND REPLACING PAVEMENT OVER IT.
BELOW: METHOD OF REINFORCING PAVEMENT OVER FILLED TRENCH TO PREVENT UNEQUAL SETTLEMENT OF PAVEMENT SURFACE.

An Opportunity for Efficiency in Public Work

The Editor of MUNICIPAL ENGINEERING:

Sir—There is an endless number of needless inefficiencies in our public work, for which the taxpayer eventually pays in hard dollars and cents, in delays, inconveniences and unsightly features of design, due to an unnecessary neglect of details. The cause of this naturally brings up the relations and respective responsibilities of the contractor and the engineer, for therein lies the seat of many troubles. Take for example paving work. Surveys are made by men more or less proficient and plans are drawn up. With the ideals of good practice in view, specifications are written out, which say just what materials are to be used and in what quantity, and how and when they are to be placed. There are no loopholes left open for the contractor who is tied down as closely as possible and be made to do as he is told.

On the other hand, the contractor looks over the estimate and perhaps reads the specifications carefully and goes out to see the proposed location of the work. He knows what work has cost him before and makes a bid accordingly, keeping in mind the keen competition of other contractors. If the contract is awarded to him he has first to put up a certified check for from 10 per cent. to 100 per cent. of the amount of his bid. When he signs the contract a surety bond is required and the law makes it necessary for him to carry employer's liability insurance, public liability and contingent liability insurance. He must take the risk of bad weather, a rising market, delayed deliveries, accidents and labor shortage. Often he is paid by municipal bonds maturing in from one to five years in towns under 100,000 and one to ten years

in towns over 100,000 population.. If he needs cash he must discount the bonds 5 or 6 per cent. and often they are hard to market at all. However, he is subject to the constant criticism of the unenlightened public. Only too often he is needlessly harassed by an unpractical inspector, steeped in book knowledge and newly acquired authority, who has passed the civil service examination. Finally, he is held responsible for the wearing quality of the work and must guarantee to fix it for a year or more. The average contractor takes these things lightly and makes the public pay, which is the only course he can honestly follow and win.

The engineering departments and the watch dogs of the treasuries of our states and municipalities have it within their power to balance up the responsibilities in our public works and to reduce the cost to the taxpayers.

In the first place, competent and experienced engineers should be employed and at salaries commensurate with their responsibilities, so that there is an inducement for them to work up in their particular line. If we must have civil service, let experience count 70 per cent, not 10 per cent. Under our present system a student can pass an examination for construction work of which he knows nothing practical at all. He gets a job and learns later at the expense of the contractor and the public.

The reason experience is so vital is that perfect specifications are impossible, local conditions cannot be foreseen and there should be an experienced engineer on the job with the knowledge and power to act immediately in an emergency, to share the responsibility and see that justice is done both the contractor and the suffering public. Moreover, the engineer in charge should be backed up by the department without delay and not hampered by ponderous wheels of authority or needless waits between weekly or monthly board meetings.

It often happens that contractors are hampered financially because estimates are not sent in promptly or their money is withheld because a telegram is answered by a letter a week or so later, or because some official is on a vacation. In such cases the contractor's money draws interest which he never gets and he must pay high rates for quick loans to meet a pay-roll or an impatient creditor.

Again, the contractor is often asked or required verbally to do things not covered in the contract, because the loss of time means poor work or added expense. He obeys without written orders so as to save time and trouble and to hurry up an estimate, trusting to the engineer and the board to give him fair play. For this he gets promises and relies on them, only to be made to wait months for his just due and he is told in the meantime that the powers that be are sorry for the delays but that things were not quite regular and they must go thru the proper channels. The result is that next time the prices for the same work are higher.

There is no panacea for many of our human failings, but it certainly behooves our officials and engineers to get together with the contractors on public work and work on a more efficient basis and with a great deal of team work.

J. T. C., Winnetka, Ill.

Records of Water Mains and Valves

THE EDITOR OF MUNICIPAL ENGINEERING:

About two years ago the water works of Aberdeen, South Dakota was placed in direct charge of the city engineer's department. On taking over the work, from the superintendent, it was found that no good records had been kept by him of the water system.

The plat which existed was found to be almost worthless for practical purposes. Many valves were shown on the wrong side of the street. Some existing valves were not shown at all and most serious of all, no record had been made showing if a certain valve was right or left. Whenever a break occurred in a main it was very difficult to locate the valves and to get the water shut off.

At one time during the winter, a break in a large main could not be shut off. The department spent two days trying to shut off the leak but was not successful. Finally all artesian wells were turned off and the entire city was without water until the break was repaired. The entire city was thus placed in great danger in case a fire had occurred at that time.

The city engineer's department, realizing the serious condition of affairs, started a survey early last spring of the entire water works system. The water was shut off in sections and a great deal of trouble was caused by not being able to close all valves completely. This was partly overcome by opening a fire hydrant in the section that was to be shut off and the valves were opened and closed until the deposit in the valve-seat had been washed out. As soon as a certain section was shut off, all valves were turned on again and all information in regard to these valves was put in a field book. Many valves were located with the aid of a magnetic needle. Some of them were from three to twelve inches beneath the surface of the ground. In all, 142 valves were found. Twenty-five of these valves were broken and twelve were found closed. Fifty valves were found of which there was no record and about one thousand feet of mains were found of which there was no record.

After all this information had been definitely obtained, a plat was made showing all mains, valves and hydrants. All valves were indicated on the plat as either right or left.

This information has proved very valuable. There have been several bad breaks in mains but with a complete record and plat no trouble was encountered in shutting off the water.

It should be the policy of the water works department to close the valves at least once a year. Some may be left closed by careless workmen and this will hinder the circulation in the mains.

A survey is now being made of all service connections.

The city has no record at present of the location of the services. All service boxes are being located and the distances from the lot lines taken. Many places have been found where there are several houses on one service with only one service box.

A plat is being prepared showing all services and their locations. When this is completed the city will have a complete record of the water works system.

After all information has been obtained the records should be kept up to date by a competent engineer. No town or city can afford to neglect this matter for it is sure to bring disastrous results some day.

FRANK LECOCQ.
City Engineer, Aberdeen, S. D.

Pay of Civil Engineers

A committee of the American Society of Civil Engineers has made a study of the compensation of civil engineers and, while it finds that those who have demonstrated their ability receive reasonable compensation, there are men not so well treated. The older engineers are themselves the worst sinners in this respect as "engineers in private practice sometimes employ men of extensive experience and presumably of good ability at salaries which young graduates with little or no experience are able to command," salaries "less than those of ordinary mechanics who have a labor organization behind them."

State legislatures are equally derelict. In Indiana, for example, county engineering officials and employes are allowed for most public work $2 to $2.50 a day, and no increase in pay and competency can be secured from the state legislature.

Collection and Incineration of Garbage in Sewickley, Pa.

A paper by Edward E. Duff, City Engineer, before the American Society of Municipal Improvements.

The Boro of Sewickley, Pennsylvania, is a residential suburb of about 5,000 population, situated on the bank of the Ohio river, some 12 miles west of Pittsburg, Pa., having an area of about 1 square mile, with a taxable property valuation of $7,250,000. Prior to 1907 the garbage was hauled to the bank of a small run within the boro limits, where it was carefully washed and subsequently buried. This system, as can be readily seen, was far from satisfactory, and the boro council took steps to relieve the board of health of their duties in this connection. A 12-ton incinerator was purchased from the Dixon Garbage Crematory Co., and erected in a suitable two-story brick building on property purchased by the council at one corner of the boro on the Ohio river bank. Subsequent to this action, it was decided to purchase sufficient cans to accommodate all the residences and to arrange for a system of collecting and incinerating the contents of the same.

System of Cans.

To supply the borough, 1,357 cans are now in active use, 1,285 of which are at the residences, and 72 on one of the wagons as exchange cans. The cans are made of galvanized iron, weigh 17¼ pounds when empty, and have a capacity of about 11 gallons. They are ordered from the following specifications, which have been revised from year to year as weaknesses have developed in any feature: 12¾ inches diameter by 19½ inches high, 20-gage iron in body and bottom, 26-gage tight-fitting lid 1½ inches deep, wrought iron hoops ⅛ inch by 1½ inch shrunk around top and bottom, heavy drop handles 4½ inches from top. All cans and lids must be thoroly galvanized and be guaranteed against leakage. These cans are purchased in lots of 200 to 400 each year at prices varying from $1.00 to $1.80 each, depending on the current prices of the raw materials. The cans are subjected to hard usage and our records show their life to be from 3½ to 4 years. One of the main sources of damage is due to householders using the can as a convenient place to burn waste paper.

The cans are placed by the collectors in any location convenient for the householder, and while their use is primarily for garbage, all kinds of refuse are found in them, such as paper, bottles, cans and even occasionally a dead cat.

Method of Collection.

Two specially constructed wagons, carrying 72 cans each, were built by the boro for the collection of the garbage. The wagons consist of a flat bed or floor set above wheels, about 4 feet above the street level, and having a few uprights around the sides to which chains are fastened to prevent the cans from falling off. The cans are placed in six rows with twelve cans to a row and as the empty cans are taken from the wagon to replace the full cans, the driver or the collector shifts the remaining empty cans to the outside.

Collections are made once each week in the residence districts, except during the summer season when there is an unusual amount of vegetable refuse, such as corn husks, watermelon rinds, etc., when three collections are made in two weeks. The hotels, restaurants, hospital and other places where an unusual amount of garbage is found have two collections each week. From one to five cans are left at each residence and as many as eleven or twelve cans at the hospital and hotels, depending of course on the actual need and the garbage accumulating. We have found that two cans per week give ample accommodation for the average family, and where it is necessary to supply more than two cans, the additional cans must be purchased by the householder, and these, of course, are exchanged the same as those owned by the boro. In collecting, the lids are not removed from the cans from the time they leave the residence until they reach the furnace, and there is consequently no nuisance created emptying from one can to another or from the can to wagon. The lids fit tight, and the cans are kept so clean that there is little or no odor about the wagon. The usual unpleasantness generally associated with a garbage wagon, such as the rattling and banging of cans and the slamming of the doors on the familiar steel wagon, is conspicuous by its absence, and had you not been previously informed, I doubt if many of you would associate the wagon and equipment with the garbage work.

SEWICKLEY GARBAGE SYSTEM. SHOWING CANS ON WAGON JUST AS THEY ARRIVE FROM COLLECTION TRIP. WAGON ON RIGHT ABOUT TO START ON COLLECTION TRIP.

Our present needs require the use of only one team of horses and one wagon in the collection work, the second wagon being loaded at the furnace for the next trip. In charge of a driver and collector, both of whom, however, acting as collectors when necessary, each taking one side of a street, the wagon makes four trips per day, bringing 285 cans to the furnace, having a total average net weight of four tons. This is at the rate of 85,540 cans per year, having a weight of 1,200 tons. An additional ton of garbage is received each day in bulk from the grocery and fruit stores, making a daily incineration of five tons and a yearly incineration of about 1,500 tons.

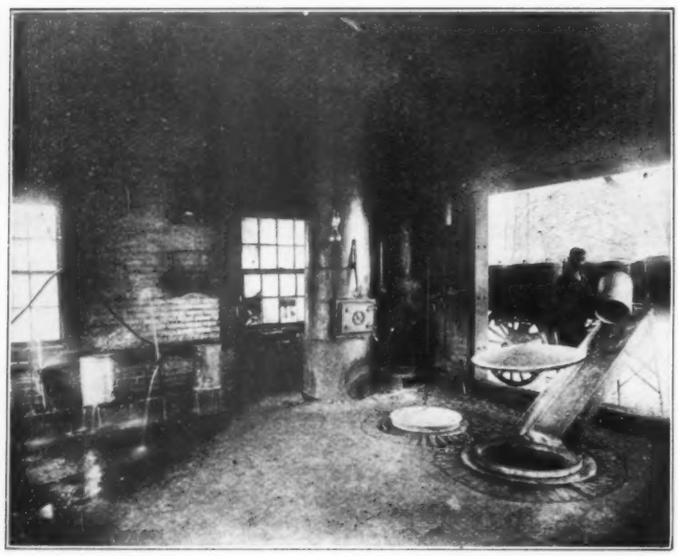
The boro is 1 mile long and approximately 1 mile wide, so that in going from the garbage furnace to the diagonally opposite corner of the boro, the garbage wagon covers on the round trip about 3 1/3 miles, making collections, however, for only ¾ of a mile in this distance. The shortest route is 1¼ miles and collections are made for only ½ mile before the wagon is loaded. Due to more convenient location of the cans in the first mentioned district, the trip is completed in 2 hours, while it requires 1½ hours to do the work on the short trip. Eighteen routes are covered by the wagon in 4½ days, in which time one collection is made thruout the boro. The remaining day and one-half is used making the second collection for the week in the business district.

Disposal at Furnace.

Upon arriving at the furnace with a load, the wagon is left in front of the big door of the furnace building, and while the driver is hitching the horses to the extra wagon, which has previously been loaded with clean empty cans, the collector assists the furnace man in emptying the garbage into the incinerator until such time as the driver is ready to leave, which is usually about five minutes.

During the winter months when the wet garbage is frozen, we find it necessary to thaw the garbage before it can be emptied from the can. A short application of a jet of steam from the hot water heater will allow the garbage to be removed. The use of bars or hooks for this purpose is prohibited because of the damage likely to occur to the cans.

In the period of 1½ hours usually elapsing between loads, the furnace men allow fifteen minutes to empty garbage into the furnace, twenty minutes to wash the cans, and twenty-five minutes to load the 72 cans on the extra wagon and arrange it for the next trip. The remaining time is spent firing the furnace, hauling ashes, etc.



SEWICKLEY GARBAGE SYSTEM. SHOWING METHOD OF EMPTYING CANS FROM WAGON INTO CHARGING HOPPER OF INCINERATOR. TWO CHARGING HOPPERS IN FLOOR IN FOREGROUND. HOT WATER HEATER IN CORNER. FOUR OF THE FIVE CAN WASHERS AT LEFT OF PICTURE. TWO CANS ON THE WASHERS AND TWO WASHERS EXPOSED.

Coal is used in the furnace to burn the garbage, while coke is burned in the flue to complete combustion. Altho the garbage plant is located within 300 yards of some of the best residences there is no complaint at any time of objectionable odor.

All the cans are thoroly cleaned with scalding water before they are again placed in active use. Five cans are placed on a rack at one time, and after they are thoroly clean, they are placed on the wagon for service. It is very seldom that complaints are received regarding dirty cans, yet most householders do not realize the work required to clean a can that we have received probably half full of dough or some other equally adhesive "left overs" from the kitchen.

Cost Data.

The total investment, exclusive of real estate, might be distributed as follows:

Building, driveway, platform and incinerator	$ 8,500
Stable	2,000
Two horses and harness	700
Two wagons	400
1,357 Cans, at average price, $1.25	1,696
Total	$13,296

The average of the yearly charges for the past eight years and ten months to January 1, 1916, as taken from the annual report of the boro clerk, show:

Wages (driver, collector, 2 furnace men)	$2,699.22
Coal and coke (about 650 tons per year)	651.81
Freight on coal, coke, firebrick, etc.	330.40
Repairs (relining furnace, grate bars, etc.)	257.40
Insurance (fire insurance on buildings and platform)	33.98
Horse feed	389.86
Blacksmithing	104.26
Cans	313.43
Extraordinary expenses (rebuild driveway and platform, etc.)	76.57
New horses	92.24
Credit (sale of cans and coal)	33.15
Total average cost per year	$4,997.98

Of this amount, one-half of the cost of wages (2 men), all of the coal and coke, 90 per cent. of freight charges, 90 per cent. of repairs, all insurance, 10 per cent. of blacksmithing and one-half of the miscellaneous, making a total of $2,616.81, are charged entirely to incineration, leaving a balance of $2,381.17 as the cost of collection. This amount is raised by about seven-tenths of a mill tax on the valuation of $7,250,000.

On the basis of the above figures, and exclusive of any interest on the investment or sinking fund charges, it has cost us $1.00 per inhabitant per year to collect and incinerate the garbage, of which amount 52 cents was spent for incineration and 48 cents for collection. On the basis of 1,500 tons per year, it has cost $3.33 to collect and incinerate each ton.

The incineration of the garbage is not new to any of you, but the question of collection has, no doubt, bothered many municipal officials. The best is none too good when one is planning an efficient sanitary garbage system, and the benefit derived from a successful incinerator may readily be counteracted by an inefficient, unsanitary system of collection. In Sewickley the residents are relieved of all responsibility regarding the purchase of cans and payments for collection. There are no unsanitary garbage wagons clattering over the streets, and there is no trail of garbage drippings from the back yard to the front street. Of course, any system will

meet with objections from a few unreasonable people, but we feel that we are giving the best service in the best manner at a minimum cost, and while our system is small in proportion to the needs of many towns or cities, I feel sure that, with proper management, the principles applied in the Sewickley system would be applicable in places many times the size.

Alcohol from Garbage

A process for making industrial alcohol from garbage and other vegetable waste was patented December 26, 1916, by Dr. F. E. Young, of Canton, O., who has two more patents pending on apparatus used in the process. It is claimed that as much grease and fertilizer are recovered as with other reduction processes, at less expense, and in addition from 5 to 10 gallons of alcohol from a ton of garbage, so that the alcohol appears as clear gain over methods now in use. The apparatus can be installed and process used in reduction plants already established, without great expense.

In the usual process of reduction the fermentable content, the sugar and starch, is purposely destroyed or caramelized by prolonged steaming at high temperature, so that it will become brittle and not interfere with the milling and screening of the fertilizer and to prevent fermentation in the finished product. The caramel adds no value to the fertilizer, as that is sold according to its nitrogen content upon chemical analysis.

In Dr. Young's process the grease and fertilizer are separated without injury to the saccharines, which are left in solution. They are then fermented in an anaerobic manner—that is, without exposure to the air—and distilled in an improved simplified column still of his invention. The material being inclosed from start to finish, and the odors being condensed for utilization, there is nothing lost and no nuisance is created. It is said to be the cleanest and most sanitary method of garbage disposal as well as the most profitable.

Garbage, of course, varies according to the season, locality, weather and many other conditions, but it usually contains about 70 per cent water and 30 per cent solids. Of the solids, about 12 per cent are fermentable, and if properly fermented will yield 50 per cent of alcohol, equal to about 7 gallons per ton of garbage.

Dr. Young retired from practice a number of years ago to engage in chemical engineering as related to conservation. This brought him in contact with many canning, sugar and preserving factories, breweries and distilleries, packing houses and garbage disposal works. Finding such vast amount of waste of the carbo-hydrates led him to investigate the manufacture of alcohol. Here he found the cause for this great waste, as well as the complete failure of the Government's Industrial Alcohol Act, to be the lack of appropriate methods and apparatus to utilize this class of material. While it is true that there had been improvements made in apparatus for the manufacture of alcohol, as, for instance, the column still, these are adapted to large production only, and large production requires first-class grain to stand long transportation.

The patents on the improvements, as well as the large distilling plants, are controlled by the same interests that produce gasoline, which results in holding down the production of alcohol in order to hold the price of gasoline up. It was necessary, therefore, to invent process and apparatus adapted to the manufacture of alcohol from these waste materials, either in small or large quantity, at the point of their origin, and save the transportation charges on both the material and the product.

Fermentable wastes may be divided into four classes according to the preliminary treatment required to fit them properly for fermentation. The fermentation and distillation are the same for all, either separate or in mixture.

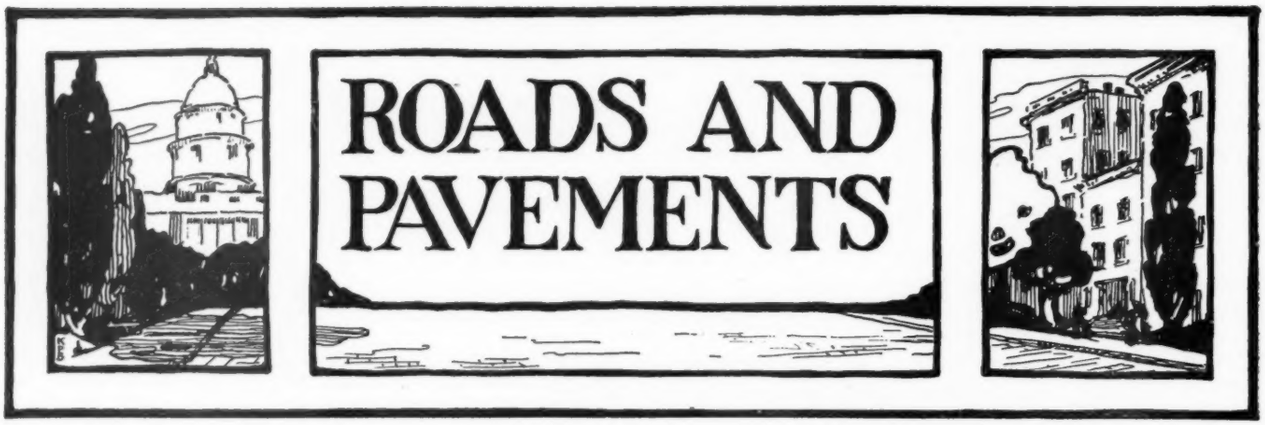
1. Sugars—Fruits, molasses, preserving, canning and sugar factory waste need only boiling and dilution.
2. Starch—Potatoes, cassava and grain of all kinds, should be ground, cooked and mashed to convert the starch into sugar.
3. Cellulose—Wood waste, kelp, straw and stable manure, must first be converted into glucose by a separate process.
4. Mixed—City garbage and market waste, being a mixture of all the above classes together with animal products, require altogether different treatment.

The mixed wastes are cooked in tall closed tanks, usually called digesters, at low pressure, by passing steam in at the bottom and up thru the garbage and out at the top thru a separator to the still to heat it. The steam carries with it the products of the fermentation that has taken place in the garbage. The enzymes of the ferment have changed the cooked starch into sugar and the raw starch is liquefied and will be converted into sugar during the fermenting process by the enzymes of the ferment without the use of malt. When the cooking is completed the water is pressed from the tankage and the grease is separated by mechanical means. The water is then cooled, yeasted and fermented without exposure to the air, which prevents decomposition of the animal products held in solution. When it is fermented it goes to the still, where it is heated by the steam from the cooker, the alcohol vapor passing over to be concentrated and condensed in the condenser. After the alcohol is distilled off, the water is called wash. It may be concentrated by evaporation and added to the tankage for fertilizer. The tankage is dried and separated, the animal portion having all of the fertilizing properties, and the vegetable portion, being principally cellulose, may be treated the same as wood waste and the glucose added to the tank water for fermentation.

The apparatus required for these preparatory operations is in common use and may be purchased in the open market. The process as outlined and the apparatus for the mechanical separation of grease, continuous and progressive fermentation and the improved still under Dr. Young's patents, in different sizes, will be placed upon the market soon. In order to obtain estimate of cost of plant and operating expense, statement of the class of material and the daily quantity to be worked should be given.

Buffalo's New Passenger Station

The union passenger station for the railroads now having stations in the neighborhood of Exchange street, Buffalo, N. Y., seems to be an impossibility and plans for a new New York Central station and terminal at Washington and Exchange streets have been presented to the terminal commission. This location requires a detour of the New York Central trains going west, and the Twentieth Century Limited, not making this detour, does not stop at Buffalo. According to the new plans, a sub-station for this class of trains will be built at Clinton and Bond streets. Other cities have moved their main railroad stations so far from the business section that Buffalo might be expected to move this station the comparatively short distance necessary to accommodate all trains in the New York Central system, but this does not seem to be possible, tho a number of people have advocated such a move.



Concrete Bridges in Austin, Texas

One hundred thousand dollars, in round numbers, is the 1916 bill of Austin, Tex., for twelve concrete briges over Shoal, Waller and other creeks within the city limits. Taking the last census report as a basis, the City of Austin spent during the year $3 per capita for concrete bridges. It is doubtful whether any other city in the Southwest has indulged in so large a per capita expenditure for concrete bridges to accommodate street traffic in recent years, barring such notable exceptions as the Corpus Christi and Galveston causeways, and the like.

The brook which made the greater part of this expenditure necessary is Waller Creek, which meanders diagonally across the map of Austin. This stream has had the habit of sweeping its bridges clean about once in five years for the last seventy-five years. For the most part, it has been bridged with steel, wood and stone-arch structures which have proven entirely inadequate to the task of resisting the swollen freshets which occur infrequently. The city has been unpleasantly bisected half a dozen times, and the traffic from west to east Austin and vice versa has been under the necessity of detouring for several miles. It is therefore in self-defense, to maintain its unity, that the city has been compelled to concrete the passageways over this stream.

The old stone arch bridges, built for the most part in the early days, are gone. One exception is the arch across the old military highway from Austin to San Antonio, constructed shortly after the Civil war, a cut of which accompanies this article. It is such structures as this one, as well as many make-shift arrangements of wood, which are now being replaced by permanent structures of reinforced concrete. The following bridges were built during the year, all of reinforced concrete:

Over Waller creek; Speedway, $7,000; First st., $12,500; Eighteenth st., $8,200; Fourteenth st., $7,000; Nineteenth st., $8,000.

Over Red river; Eleventh st., $5,000.

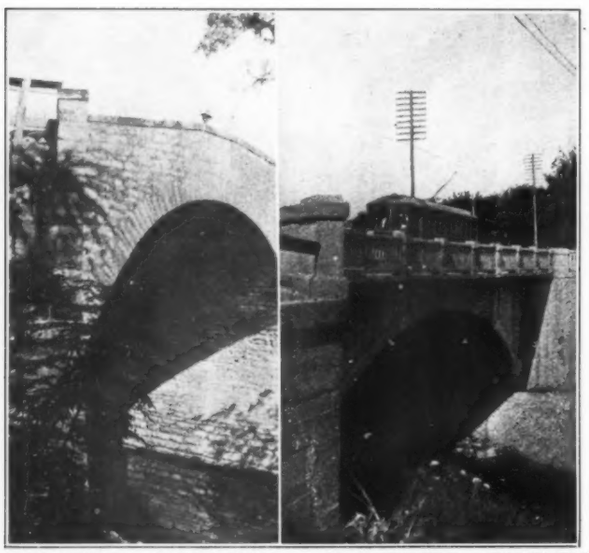
Over Shoal creek; Camp Mabry road, $4,000; Twelfth st., $9,175.

Over Blum creek in South Austin, $3,500.

Over ravine in South Austin, $2,500.

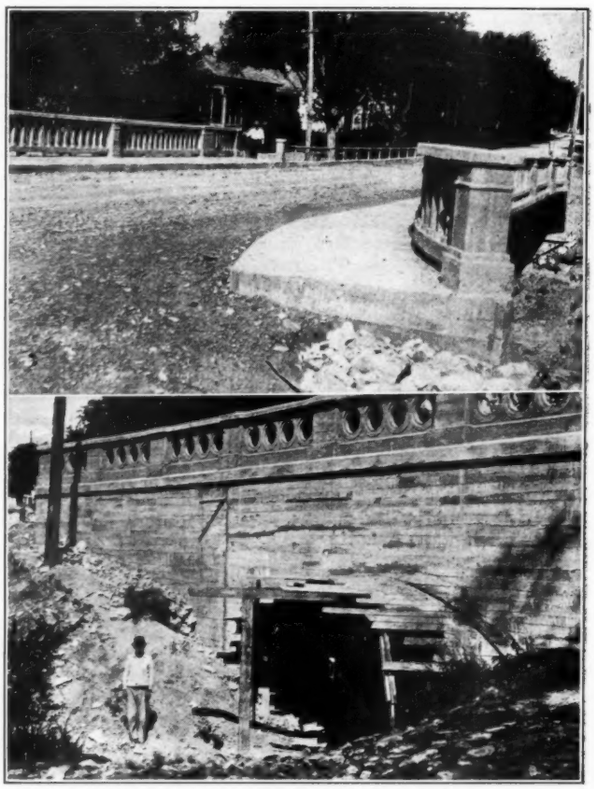
Retaining wall 20 ft. high, 200 ft. long, Waller creek, 3rd st., and East ave., $3,000.

Besides these, bridges will be built over Waller creek, at



OLD STONE ARCH BUILT ABOUT 1865. ONE OF THE FEW NOT YET REPLACED BY REINFORCED CONCRETE.

REINFORCED CONCRETE ARCH OVER WALLER CREEK AT FIRST STREET, REPLACING STONE ARCH.



REINFORCED CONCRETE BRIDGE OVER WALLER CREEK AT EIGHTEENTH STREET, AUSTIN, TEXAS.

REINFORCED CONCRETE ARCH OVER WALLER CREEK AT SPEEDWAY UNDER CONSTRUCTION.

Asphalt Pavements Laid in 1916 and Proposed for 1917.

Descriptions of pavements as laid, cost per square yard and total cost. **Design, Cost and Quantity are shown.**

State and City	Laid in 1916 Sq. Yds.	Concrete Thick	Concrete Propor.	Binder Thick	Binder Propor.	Surface Thick	Surface Propor.	Cost per sq. yd. Pav. and Found.	Total Cost Inc. (1)(2)(3)(4)	Kind Asphalt Used	Estimate for 1917
Arizona—											
Phoenix	32,089	....	.....	.....	.....	...	.....	$1.24	$63,850	Tarvia	.....
Arkansas—											
Ft. Smith	26,000	....[8]	.....	.....	.....	2	.....	1.08	.....	Texas[54]	9,453
Hot Springs	.....	...	.....	.....	.....	...	.....	.....	.....	.....	25,000
California—											
Long Beach	11,972	4	1:3:6	1	.....	1½	.....	1.56(1)	.....	.....	150,000[9]
Los Angeles	519,559	3-6	1:3:6	0-1	.....	1-2	.....	0.81-1.35	634,477	.....	.....
Petaluma	35,000	5	1:2½:5	1½	.....	...	.....	0.81	4,550(1)	S. O. D.	95,243
San Diego	12,043	5	1:3:5	1	.....	2	.....	1.50	.....	.....	.....
San Francisco	381,523	6	1:2½:7	1½	.....	1-2½	.....	.....	7,305,416	Union Standard	.....
San Luis Obispo	.....	....	.....	.....	.....	...	.....	.....	.....	.....	20,000
Santa Ana	20,950	4	1:8	.....	.....	...	.....	.....	1.035	.....	.....
Santa Barbara	15,000	4-4½	1:3:6	.....	.....	1½-2	.....	1.35	45,700	California	82,000
Santa Monica	34,910	5	1:3:6	1	.....	2	.....	1.215	62,097	California	.....
Colorado—											
Ft. Collins	3,312	....	1:2:3	.....	.....	...	.....	1.18	1.36	.....	some
Connecticut—											
Hartford	32,195	6	1:2:3	1½	25:600	1½	.....	1.58	56,804	Aztec	47,320
New Haven	92,742	6	1:3:6	1½	5-8%[11]	1½	10½-12½%[11]	1.84	0.96[8]-1.96	U. S. Asphalt	30,000
Stamford	9,344	5	1:6	0	0	2	.....	1.64	.....	Aztec	.....
District of Columbia—											
Washington	154,076	6	1:3:7	1½	.....	2½	.....	1.665	2.50	Aztec-Montezuma	150,000
Georgia—											
Atlanta	32,767	....[114]	.....	0	.....	2	.....	.....	.....	Natural	24,575
Illinois—											
Aurora	22,210	5	1:7G	1½	.....	1½	.....	.....	1.75(1)	Mexican-Trinidad	18,000
Berwyn	.....	....	.....	.....	.....	...	.....	.....	.....	.....	132,800
Chicago	1,248,000	6	1:3:6	1½	.....	2	.....	1.893	2.849	Mexican-Trinidad	.....
Cicero	78,135	6	.....	.....	.....	2	.....	2.35	160,412	.....	72,342
Freeport	.....	....	.....	.....	.....	...	.....	.....	.....	.....	20,000
Lincoln	.....	....	.....	.....	.....	...	.....	.....	.....	.....	10-15,000
Moline	36,059	5	1:3:6	1½	.....[10]	2	.....[10]	1.81	93,857	Mexican	30,000
Oak Park	2,574	6	1:3:6	1½	.....	2	.....	1.82	7,085	Trinidad	.....
Rock Island	6,254	5	1:3:6	1½	.....	2	.....	1.75	.....	.....	.....
Indiana—											
Elkhart	22,950	6	1:3:5	1	1:3.5:10.5	1½	1:1:5.5	1.80	57,950	Trinidad	10,000
Ft. Wayne	45,112	6	1:3:6	1[11]	.....[103]	1½	.....[103]	1.70	107,229	Trinidad	20,000
Goshen	24,046	6	1:3:5	1	.....	1½	.....	1.56	49,013	Trinidad	.....
La Porte	38,325	6	1:3:6	1	1:26:103	1½	1:1.5:7	1.78	74,564	Trinidad	.....
Logansport	44,618	5	1:3:5	1½	.....	1	.....	.....	1.95(1)	Trinidad	27,300
Michigan City	.....	....	.....	.....	.....	...	.....	.....	.....	.....	15,125
Muncie	10,000	....[35]	1	.....	2	...	.....	1.50	.....	Trinidad	.....
New Castle	4,482	5	1:3:6	1½	.....	1½	.....	1.60	10,280	Trinidad	.....
Richmond	23,791	6	1:2:5	1	.....	1½	.....	1.75	42,483	Trinidad	.....
South Bend	18,709	6	1:7G	1½	4.6%[11]	2	11%[11]	1.81	49,055	Trinidad	45,443
Vincennes	107,506	5	1:5	1	5.5%[11]	1½	10.5[11]	1.66	247,037	Trinidad	68,000
Wabash	16,941	5-6	1:3:5	1	.....	1½	.....	1.75	44,862	Trinidad	0
Iowa—											
Britt	35,796	5	1:3:5	1	.....	1½	11%[12]	1.68	85,964	Texaco	.....
Forest City	19,523	4	1:3:5	1½	.....	1½	.....	1.66	45,325	Texaco	.....
Mason City	131,489	5	1:3:6	1	6%[12]	1½	11%[12]	1.68	.....	Trinidad	100,000
Sioux City	11,000	5	1:2½:4	1½	.....	2	.....	2.10	23,100	Trinidad	.....
Waterloo	14,130	6	1:3:6	1	.....	2	.....	2.10	.....	Trinidad	5,000
Kansas—											
Leavenworth	.....	....	.....	.....	.....	...	.....	.....	.....	.....	25,000
Newton	113,200	4	1:2:4	0	.....	2	.....	1.24-1.27	227,000	.....	25,000[9]
Wichita	.....	....	.....	.....	.....	...	.....	.....	.....	.....	30,000
Kentucky—											
Lexington	50,000	6	.....	1	.....[13]	2	.....	2.10	3.20	Trinidad	.....
Louisville	47,747	6	1:3:6	1-1½	.....	2	.....	1.74	.....	Trin.-Cal.-Mex.	80,000
Owensboro	.....	....	.....	.....	.....	...	.....	.....	.....	.....	75,000[9]
Maryland—											
Baltimore	9,257	4-6	1:3:6	1½	.....	1½	.....	1.37	18,484	.....	.....

State and City	Laid in 1916 Sq. Yds.	Concrete Thick	Concrete Propor.	Binder Thick	Binder Propor.	Surface Thick	Surface Propor.	Cost per sq. yd. Pav. and Found.	Total Cost Inc. (1) (2) (3) (4)	Kind Asphalt Used	Estimate for 1917
Massachusetts—											
New Bedford	2,833	5	1:3:5	1	5:95	1½	10:11:79	.....	.....	Aztec	.....
Michigan—											
Detroit	12,408	6	1:3:6	1½	.....	2	.....	2.04	2.98(1)(2)	Bermudez-Mex.-Std.	.....
Flint	104,000	6	1:5	1	.....	1½	.....	1.31	234,000	Bermudez-Aztec	128,000
Grand Rapids	1,178	5	1:3½:7	1½	8%[12]	1½	10%[12]	1.90	2,900	Magnolia	.....
Saginaw	6,780	6	1:3:6	1	.....[19]	1½	.....[19]	1.80	2.50	Trinidad	24,000
Minnesota—											
Duluth	21,300	6	1:3:6	1	6%[11]	2	.....	2.14	58,637	Trinidad	5,000
Eveleth	.....	....	.....	.....	.....	...	.....	.....	.....	.....	25,000[9]
St. Paul	205	8	1:2½:5	1½	.....	1½	.....	3.00	900	Trinidad	2,138
Mississippi—											
Laurel	42,000	4	1:3:5	.....[13]	.....	1½	.....	1.525	1.60(1)	Standard Oil	10,000
Vicksburg	2,996	4	1:3:5	.....[13]	.....	2	.....	1.60	69,785	Stanacola	0
Missouri—											
St. Louis	130,475	5-7	1:3:6	1¼	.....	1½	.....	1.90	270,770(1)(2)	Several	85,000
Springfield	1,438	4	1:3:6	.....	.....	2	.....	1.45	1.65(1)	Natural Rock	.....
Nebraska—											
Hastings	84,989	4	1:5G	1½	5%	1½	10%	1.46-1.54	175,000	Trinidad-Texaco	129,000
Lincoln	26,837	5	1:3:6	1½	.....	1½	.....	.....	1.84(1)	Trinidad-California	.....
Omaha	23,130	5	1:3:6	1½	.....	1½-2	.....	1.90	58,864(1)	Mex.-Berm.	20,000
New Jersey—											
Bayonne	89,600	5	1:3:6	1½	.....	1½	.....	1.80	.....	Bermudez & Oil	78,000
Bloomfield	3,758	6	1:3:5	2	.....	...	.....	1.45	11,272	Standard-Trinidad	3,000
Elizabeth	25,000	6	1:3:6	1½	.....	1½	.....	1.60	1.80	Mexican	.....
Jersey City	2,323	5	1:3:5	1½	.....	2	.....	.....	4.537(1)(2)	.....	3,000
Passaic	24,358	6	1:3:6	1½	.....	1½	.....	.....	1.65	1.92[1]	44,000
South Amboy	.....	....	.....	.....	.....	...	.....	.....	.....	.....	20,000
Trenton	37,650	5	1:3:6	1	.....	1½-2	.....	2.04-2.10	.....	Bermudez	30,000
New Mexico—											
Roswell	7,337	6	1:6	.....	.....	2	.....	1.55	14,179(1)(2)	Oil	1,160
New York—											
Albany	40,125	6	.....	1	.....	2	.....	1.77	.....	Trinidad-Standard	30,000
Buffalo	221,674	6-9	1:8-1:10	1½	.....	2	.....	.....	772,467	Trinidad	225,000
Schenectady	16,036	6	1:3:6	.....	.....	2	.....	1.39	43,071	Mexican	25,000
Syracuse	7,407	6	1:3:6	1	.....	2	.....	1.68	19,088	Montezuma	182,018[9]
North Carolina—											
Asheville	7,721	5	1:2½:5	.....	.....	...	.....	1.81	16,126	.....	.....
Durham	8,000	4	1:3:6	1½	.....	1½	.....	1.73	20,000(1)(2)(3)	Montezuma	.....
Fayetteville	22,361	....	.....	.....	.....	...[14]	.....	.....	.....	.....	.....
North Dakota—											
Bismarck	.....	....	.....	.....	.....	...	.....	.....	.....	.....	150,000
Ohio—											
Canton	16,040	5	1:3:5	1½	.....	1½	.....	1.79-1.85	52,236	Montezuma	57,051
Cincinnati	2,351	6	1:3:6	1.5	8%[11]	1.5	11%[11]	2.25	6,322[15]	Natural	.....
Cleveland	24,149	....	.....	1	.....	2	.....	2.08-2.25	.....	Trinidad-Bermudez	.....
Conneaut	14,924	6	1:3:6	1	.....[16]	2	.....[17]	1.40	31,320	Aztec	.....
Findlay	.....	....	.....	.....	.....	...	.....	.....	.....	.....	11,931
Lakewood	13,790	6	1:3:6	1	.....[18]	1½	.....	1.99	26,837	Montezuma-Aztec	.....
Lorain	7,500	6	1:3:6	1	.....	1½	.....	1.90	3.50	Trinidad-Mexican	50,000[9]
Toledo	43,357	6	1:3½:6	1½	.....	1½	.....[19]	1.99	3.38	.....	.....
Van Wert	14,033	6	1:2:4	.....	.....	2	.....	1.68	33,686	Trinidad	0
Washington C. H.	15,519	6	1:5	1	.....	1½	.....	1.78	35,396	Trinidad	6,000
Xenia	25,000	6	1:3:6	1	.....	1½	.....	1.98	3.14	Trinidad	.....
Oklahoma—											
Sapulpa	.....	....	.....	.....	.....	...	.....	.....	.....	.....	8,000
Oregon—											
Astoria	.....	....	.....	.....	.....	...	.....	.....	.....	.....	45,000[9]
Pennsylvania—											
Allentown	42,750	4-6	1:3:6	1	.....	1½-2	.....	1.89-2.03	86,050(1)	Trinidad	.....
Erie	30,284	5	.....	1½	.....	1½	.....	1.68(1)	56,753	Aztec	70,000
Hazleton	10,888	6	1:2:4	1	.....	...	.....	1.65	.....	Mexican-Texaco	16,000
Johnstown	.....	6	1:3:5	1	.....	2	.....	.....	.....	Natural Lake	14,088
Pittsburgh	74,134	6	1:3:6	1½	5-8%[11]	1½	10-13½[11]	2.15	2.38[20]	.....	.....
Wilkes-Barre	38,925	6	1:3:6	1½	.....	2	.....	2.00	.....	Montezuma	.....
York	14,888	6	1:3:5	1	.....	2	.....	.....	1.85	Trinidad	10,000
South Carolina—											
Charleston	35,340	4-5	1:3:6	1½	.....[21]	1½	.....[22]	1.43[23]	.....	Aztec	.....
Greenville	10,000	4	1:3:6	1	.....	2	.....	1.55(1)	.....	Trin.-Mex.-Oil	65,000[9]
Tennessee—											
Chattanooga	29,127	old base		2	.....	2	.....	0.96	1.23	Distillate	.....

Texas—												
Amarillo	29,737	5	1:8	0	.....	2	.....	1.79	.....	Natural Rock	10,000[9]
Beaumont	66,727	5	1:2½:5	.....	.....	2	.....	1.90	146,303(1)(2)	Uvalde Rock	.....
Cleburne	.....	5	.....	1½	.....	2	.....	2.00	(1)	Trinidad	30,000
Dallas	54,178	5	1:8	2	.....	...	.....	.....	132,517	Uvalde Rock	173,214
Denison	11,606	5	1:3:6	.....	.....	2	.....	1.55	1.64	Texaco	.....
Houston	2,288	6	1:3:6	.....	.....	2	.....	1.90	4,900	Texaco	0
Port Arthur	.....	....	.....	.....	.....	...	.....	.....	.....	.....	60,000
San Antonio	21,790	5	1:3:6	.....	.....	2-3	.....	1.85	2.05	Uvalde Rock	60,000[9]
Taylor	22,000	5	1:2:4	.....	.....	2	.....	1.84	80,000	Uvalde Rock	0
Utah—											
Ogden	10,585	6	.....	1	.....	1½	.....	1.95	25,403(1)(3)(4)	Trinidad	.....
Salt Lake City	100,300	5-6	1:3:6	1½	.....	1½-2	.....	1.80-2.24	315,725	Uvalde R.-Cal.	110,000
Virginia—											
Norfolk	42,421	4-5	1¼	.....	1½	...	.....	.....(1)	1.30-1.49	Mexican	30,820
Washington—											
Aberdeen	19,520	6	1:3:6	.....	.....	2	.....	1.52	39,842	Standard Oil	.....
Bellingham	104,402	6	1:3:5	¾	.....	1½	12[12]	1.15-1.40	226,016	California	.....
Olympia	4,205	5	1:3:6	0	.....	2	.....	1.16	11,500[15]	California	.....
Seattle	146,173	5-6	1:3:6	1	.....	2	.....	1.40	.....	California	100,000
Spokane	47,071	4-5	1:3:6	1	.....	1½-2	.....	1.05-1.25	89,522	California	10,000
Tacoma	1,888	5	1:3:6	1	5-8[11]	1½	11-13.5[11]	1.38	4,722	Pen. 70-80	.....
Vancouver	1,250[24]	4	1:3:5	.....	.....	2	.....	1.85	2,512	.....	.....
West Virginia—											
Charleston	6,450	5	1:2½:5	1	5-8[11]	1½	9½-13½[11]	1.863	2.679	Aztec	.....
Wisconsin—											
Beloit	48,510	5	1:3:6	1	.....	1½	.....	1.25[25]	76,288	Trinidad-Aztec	0
Green Bay	.....	....	.....	.....	.....	...	.....	.....	.....	.....	15,000
Madison	43,168	5	1:3:5	1	6:22:72	1½	12:10:78	1.60	93,765	Trinidad	50,000
Racine	20,851	5	1:3:5	1	.....	2	.....	1.99(1)	48,558	Trinidad	28,084
Wyoming—											
Cheyenne	.....	....	.....	.....	.....	...	.....	.....	.....	.....	10,000

[1] Per square yard.
[2] Contract awarded.
[3] Linear feet.
[4] Miles.
[5] Blocks of street.
[6] Includes boros of Blakley, Dickson City, Jermyn, Jessup, Olyphant, Throop.
[7] Will lay considerable in 1917.
[8] Old brick or macadam foundation.
[9] Kind not yet decided.
[10] American Society of Municipal Improvements specification.
[11] Bitumen.
[12] Asphalt cement.
[13] Paint coat.
[14] Top coat.
[15] Includes cost of water mains also.
[16] A. C., 47; sand, 134; fine gravel, 134; 1-in. stone, 688.
[17] A. C., 108; dust, 150; sand, 700.
[18] Close binder.
[19] 3 parts stone, 2 parts sand, 7 to 10% bitumen.
[20] Repaving including grading and removing old pavement.
[21] A. C., 30; sand, 127; stone, 508.
[22] A. C., 82; filler, 105; sand, 563.
[23] 4-in. concrete, $1.43; 5-in., $1.53.
[24] 1,250 sq. yds. on concrete base cost $1.85, or total of $2,512; 2,650 sq. yds. on crushed rock base cost $1.52, or total of $4,228.
[25] 34,957 sq. yds. using Aztec asphalt cost $1.25 a sq. yd.; 13,553 sq. yds. using Trinidad asphalt cost $1.37 a sq. yd.
[26] Cost $2.12 a sq. yd. with concrete base; $1.50 with bituminous concrete base.
[27] Crushed stone base.
[28] ¼ gal. bit. cement per sq. yd.
[29] $1.30 for 2½-in. top only, $1.32 for 2-in. top and 2-in. binder only; $1.48 for 1½-in. top on 4-in. crushed rock; $1.58 for 1½-in. top on 4-in. concrete, 1½-in. top on 4-in. bituminous base, 2-in. top on old macadam.
[30] Oil and screenings ⅜ in. thick, 1 gal. of oil per sq. yd.
[31] 8% bitumen, 11% dust, 53% sand, 28% stone.
[32] Cost of sidewalks also included.
[33] 4-in. base cost 57 cents and 2-in. top cost 70 cents.
[34] Texaco asphalt 460 lb. per batch or 8.2%; stone dust 300 lb., cement 300 lb., together 10.7%; sand, 2,900 lb., or 52%; chats, 1,625 lb. or 29%. 30% of the sand must pass No. 10, 20 and 30 screens, 36%, No. 40 and 50 screens, and 34% No. 80, 100 and 200 screens.
[35] Laid on old foundation.
[36] 2,540 sq. yds. Topeka mix with Montezuma asphalt; 11,570 standard bituminous concrete, averaging 7½% asphaltic cement, using Axtec asphalt.
[37] 2 cu. ft. of ½-in. stone; 3 cu. ft. of torpedo sand; 8 gals. of asphalt.
[38] 5 cents added to this price for maintenance.
[39] National paving; asphalt, 18%, dust 82%.
[40] Hot mix bituminous base, 1½ in. rock to dust with about 8% bitumen mixed hot, raked, and rolled with 10-ton roller.
[41] Over old macadam base.
[42] Open specifications.
[43] With 4-in. concrete base, $1.42; 5-in., $1.50.
[44] Bituminous base.
[45] 7,201 sq. yds. on 4-in. concrete foundation, at $1.58; 30,538 sq. yds. on 5-in. concrete foundation, at $1.75 a sq. yd.
[46] $1.85 on concrete base; $1.35 on natural base.
[47] Crushed stone 50 lbs.; sand 36; stone dust 7; asphaltic cement 7.
[48] $1.55 on 6-in. concrete, $1.58 on 4-in. concrete, $1.05 on old macadam base.
[49] Oiled.
[50] 982 sq. yds. laid 4 in. thick cost $0.585 a sq. yd.
[51] 2,000 sq. yds. of Amiesite on concrete base cost $1.75 a sq. yd.
[52] 6 in. Telford, 3 in. macadam.
[53] 2-in. top of 1½-in., ½-in. and stone chips.
[54] Cost of 1,863 sq. yds.
[55] Price includes wire fabric reinforcement.
[56] Premolded expansion joint.
[57] Bituminous wearing surface.
[58] Total cost of all three varieties.
[59] Hassam Bi-co-mac.
[60] Bituminous.
[61] Along curbs.
[62] One thickness tar paper in transverse joints.
[63] Granite in wearing course.
[64] Baker protection plates.
[65] Kahn bar joint protection.
[66] Sandwich transverse joints.
[67] Cost of pavement only.
[68] Cross expansion joints every 25 ft. on alleys and 50 ft. on streets.
[69] Trap rock in wearing course.
[70] Creosoted wood blocks for joints.
[71] Two contraction and one expansion joint per 100 ft.
[72] Wearing surface is 2 coats of Tarvia A and screenings and is about ⅜ in. thick.
[73] City furnishes coarse aggregate.
[74] Transverse expansion joints are put in diagonal lines, 25 ft. apart. c. to c.
[75] Transverse joints every 20 ft.; longitudinal joints are used where pavement is more than 24 ft. wide.
[76] 1,630 sq. yds., two-course, 1:2½:4 base, $1.65 sq. yd. 8,388 sq. yds., one-course, 1:2:3, $1.45.
[77] Baker joints with Elastite filler 100 ft. apart, alternating with a specified contraction joint.
[78] If not reinforced base is 7 in. thick, cost $1.37 sq. yd. If reinforced base averages 6½ in. thick, cost $1.49 to $1.53 per sq. yd., or $1.63 to $1.68 with integral curb.
[79] Binder proportions are 55 lb. A. C., 275 lb. sand, 550 lb. stone. Surface coat proportions are 160 lb. A. C., 85 lb. filler, 768 lb. sand.
[80] 1½-in. first coat 1¼ gal. per sq. yd.; 1 in. surface coat, ¾ gal. per sq. yd. Bermudez asphalt.
[81] 26,165 sq. yds. on 4-in. water bound macadam base cost $1.17 a sq. yd.
[82] Reinforced with triangular mesh if over 20 ft. wide.
[83] 1½ in. of crushed rock and 2 in. of bitulithic wearing surface.
[84] Bituminous base.
[85] Sand and cement.
[86] Sand.
[87] Sand filler with pitch for 3 ft. width crest to curb.
[88] Surface coat 1 in. crushed stone with hot road oil applied.
[89] 1½ in. Barrett pitch filled joint along each curb, ½ in. ditto across streets at intersections.
[90] 1-in. expansion joints along curb; ½-in. joints every 50 ft.
[91] 12-lb. treatment of blocks.
[92] Sandstone.
[93] Elastite expansion joints.
[94] Asphalt compound, premmolded, along curb, width proportioned to width of roadway.
[95] Cement grout or bituminous filler, the latter 35% pitch, 15% asphalt.
[96] Stone chips.
[97] Filler is half sand and half paving pitch.
[98] Eight-in. soft - coal - cinder base.
[99] 8,103 sq. yds. on natural soil base; 6,530 on 6-in. gravel base; 1,331 on 6-in. crushed rock.
[100] Cost $1.92 with 3-in. vertical fiber blocks; $2.15 with 4-in. repressed blocks.
[101] Cost $1.77 with 3-in. vertical fiber blocks; $1.97 with 4-in. repressed blocks.
[102] Hillside brick.
[103] Also 4,990 sq. yds. with filler one part sand and one part paving pitch.
[104] Mortar bed.
[105] Granulated slag.
[106] 6½ in. slag; 1¼ in. sand; 4-in. brick.
[107] Filler is grout, bituminous or pitch mastic as specified. Latter proportions 85% pitch, 15% asphalt.
[108] 50 lb. A. C.; 800 lb. 3-in. stone.
[109] 170 lb. A. C.; 80 lb. dust; 800 lb. sand.
[110] 140 lb. A. C.; 575 lb. sand; 275 lb. stone; 95 lb. dust.
[111] Telford base.
[112] Warring-Underwood.

Fifteenth and Sixteenth streets, which will cost more than $10,000. The deepening of the channel under all the bridges on both Shoal and Waller creeks runs the bill up to nearly $100,000.

The new bridges are modern and up-to-date in every particular, most of them being artistic in design and pleasing in appearance. This is especially true of the Eighteenth street bridge, a cut of which accompanies this article. No two of these bridges follow the same pattern, giving a pleasing variety. All of the larger structures are wired for electric lights, and the First street bridge is now equipped with cluster street lights, while the Eighteenth street bridge is lighted with another variety of ornamental street light. Moreover, all of these bridges have a 6-ft. sidewalk on either side, and the width of the roadway is ample in each case to accommodate all the traffic. The width of the bridges from curb to curb varies from 26 to 40-ft., or, including walls and sidewalks, from 38 to 52 ft.

Altho this may seem a rather large concrete bill for a small city in one year, the municipality receives in return therefor the assurance that life and property on these two unruly streams will not be constantly menaced, and the inconvenience of having the city cut into two or three in flood-time is definitely and finally done away with.

Pneumatic Concreting of the Van Buren Street Tunnel

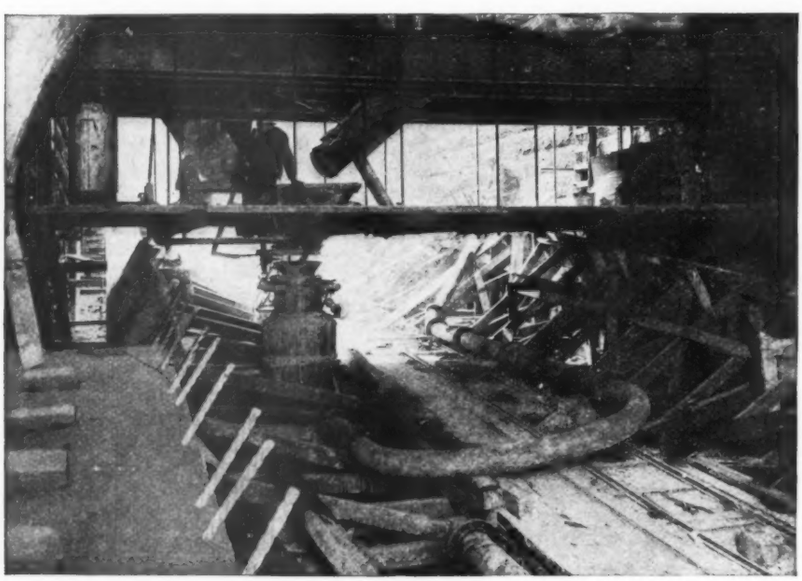
By H. B. Kirkland, President Concrete Mixing and Placing Company, Chicago

One of the more recent uses to which compressed air has been adapted is the mixing, conveying and placing of concrete. This process depends upon adiabatic expansion of the air, which is released thru an 8-inch pipe and carries a ½-yard batch of concrete at a time. This process has been used mostly for tunnel lining work and a recent example is that of the Van Buren street tunnel of the Chicago Surface Lines.

The Van Buren street tunnel carries a double-track street railway under the Chicago river and under the tracks of the Union Station. The proposed new Union Station required certain sub-passageways which would be interfered with by the location of the Van Buren street tunnel and for this reason it was necessary to change the grade so that the tunnel would pass under the proposed passageways of the new station. To make this change a new grade was established, lowering the tunnel under Canal street about 15 feet, and a new section, slightly less in width than the old tunnel, was designed. First the side walls and roof of the new tunnel were built, but instead of being carried down to their proposed depth in the first construction operation, these walls were built to the level of the old tunnel floor or invert and then the new roof was built upon them. Afterward the new side walls were extended down to the new level by underpinning—that is, alternate 10-foot sections of wall were excavated and filled with concrete down to the depth of the wall, and the remaining 10-foot sections were excavated, and the concrete invert constructed, thus completing the tunnel section.

Most of the concrete was mixed and placed by the pneumatic method. Inasmuch as the section of tunnel which was lowered was only 700 feet long, it was possible to locate the pneumatic mixer with bins above it at about half way between the ends of the work, thus making the maximum distance which it was necessary to convey concrete about 350 feet. This central point was at the tunnel portal. Bins were located here over the mixer, and the top of the bins came to the level of the street, so that materials brought in motor trucks were dumped directly into the bins and ran by gravity directly to the mixer.

The pneumatic mixer consists of a conical shaped hopper with a door at the top which is closed air tight after receiving each batch of unmixed ingredients for concrete. Air is admitted into the mixer at 80 to 100 pounds pressure above the batch and also below it, at the point of the conical shaped hopper. The lower air pipe is directed at the center of the 8-inch conveyor pipe which leads away from the machine to the point for depositing concrete. This stream of air mixes and conveys the concrete. The other air, admitted above the batch, merely forces the batch downward and into contact with the lower air stream. An air receiver of about 120 cubic feet capacity was located near the mixer and air was supplied by a Sullivan angle compound motor-driven air compressor, belt connected. The compressor has a rated capacity of 628 cubic feet of free air per minute, a size which is ample for placing one batch of concrete per minute at a distance of 300 feet. For shorter distances the number of batches could be increased and for a larger distance, the batches are less in number per minute.



PNEUMATIC CONCRETE EQUIPMENT IN THE VAN BUREN STREET TUNNEL.

The amount of air consumed in general in the mixing and placing of concrete by this method, is dependent on the specific gravity of the material conveyed, the size of pipe used, the size of storage reservoir, the horizontal and vertical distance of discharge, the number of bends in the discharge pipe, and, last but not least, upon the operator.

Accompanying are tables of theoretical capacities for continuous operation.

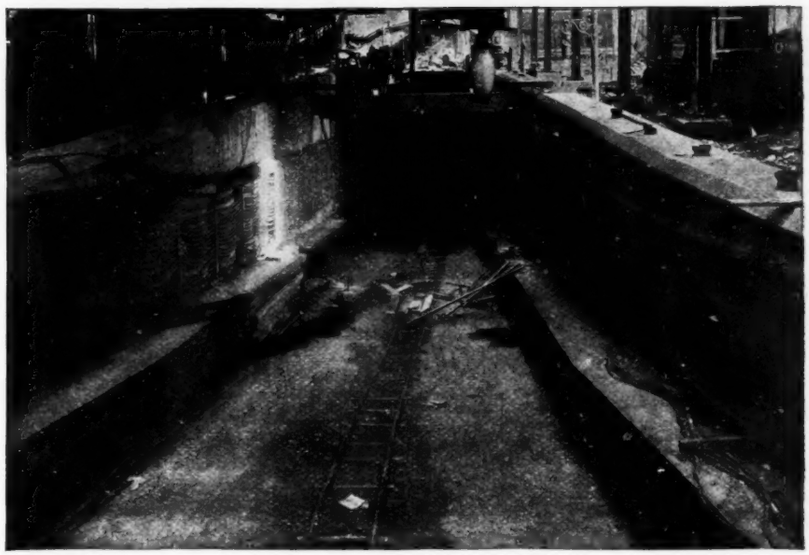
The figures in Table I are based on observation for the shorter distances of discharge and are computed for the longer distances. At the St. Louis water works tunnel the air consumption was from 1.2 to 1.7 cu. ft. per linear foot of discharge pipe. At the Richmond tunnel, San Francisco, the consumption was 1.3 cu. ft. per linear foot of pipe. Another tabulation given by H. A. Leeuw and stated to be based on three years' study and experience is shown in Table 2.

Time-Studies.—Tables 3 and 4 give two time-studies which were made during the course of a regular day's run on

one job. The air supply was about 60 cu. ft. per minute and a ½-yard mixer was used. It was charged by hand from overhead bins operated by sliding gates immediately over the measuring hopper; two laborers controlled the sand and stone gates and one laborer operated the gate to the measuring hopper and also the air valves. Still another laborer operated the water valve and assisted the mixer operator, making five men at the mixer.

Note that a 600-foot compressor was used and that the average time of waiting for the air pressure to come up was 17.2 seconds in time-study No. 1, in which the distance was 350 feet. In study No. 2, in which the distance was only 102 feet, there was no wait for air pressure.

The Van Buren street tunnel work was done by the Chicago Surface Lines, under direction of Mr. John Z. Murphy, electrical engineer, and Mr. J. W. Harris, tunnel engineer.



GENERAL VIEW, VAN BUREN STREET TUNNEL ALTERATION.

TABLE III—TIME-STUDY NO. 1

Consec. No. of shot.	Charging mixer, sec.	Closing door, sec.	Discharging mixer, sec.	Wait for rise in air pressure, etc.
1	10	4	13	23
2	10	2	13	11
3	9	3	17	15
4	8	5	14	16
5	10	5	17	20
6	11	2	20	14
7	11	6	19	20
8	9	6	15	19
9	10	5	18	..
Average	9.8	4.2	16.2	17.2

Average time per shot, 47.4 seconds. Length of conveyor pipe line, 315 feet. Vertical rise of pipe, 15 feet. Bends in pipe, 270 degrees.

TABLE IV—TIME-STUDY NO. 2

Consec. No. of shots	Charging mixer, sec.	Closing door, sec.	Discharging mixer, sec.
1	8	3	7
2	5	3	11
3	9	1	9
4	7	4	8
5	6	4	9
6	7	5	9
7	5	5	12
8	7	9	11
9	6	3	10
10	5	5	11
11	7	5	10
12	5	4	13
Average	8.7	4.4	10.0

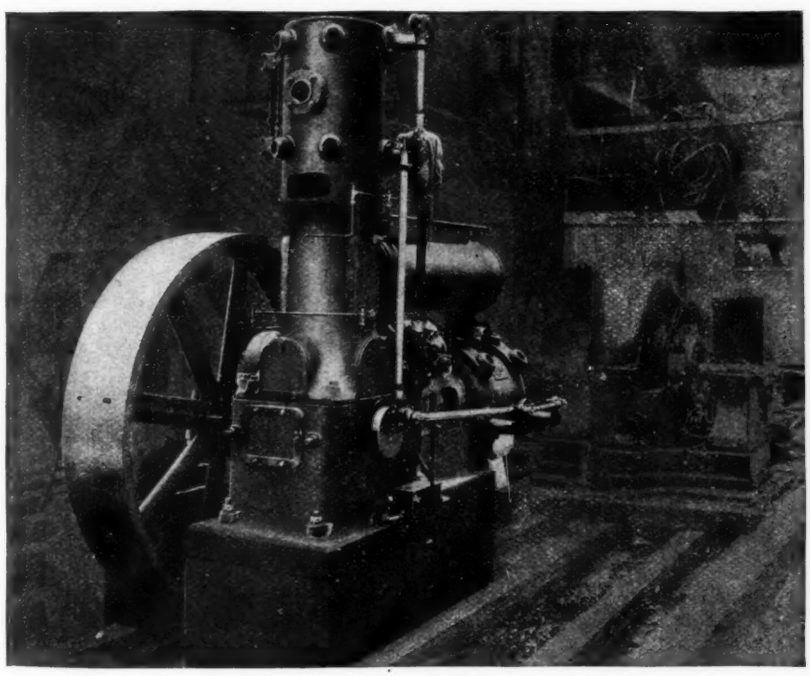
Average time per shot, 23.1 seconds. Length of conveyor pipe, 102 feet. Vertical rise of pipe, 37 feet. Bends in pipe line, 205 degrees.

TABLE I.

Distance, feet	100	200	500	800	1,000	1,200	1,500	2,000	2,500
Time of shooting, minutes	10	15	25	40	50	60	75	100	125
Time of loading, sec.	20	20	20	20	20	20	20	20	20
Time per batch, sec.	30	35	45	60	70	80	100	130	145
Batches per minute.	2.0	1.8	1.3	1.0	.85	.75	.6	.46	.41
Batches per hour.	120	108	78	60	51	45	36	27	24
Yards per hour.	40	36	26	20	17	15	12	9	8
Actual free air required, cu. ft. min.	400	720	1,300	1,600	1,700	1,800	1,840	1,840	2,000
Size of air reservoir, cubic feet	50	100	150	240	300	360	450	500	750

TABLE II—CUBIC YARDS OF CONCRETE PER HOUR, MIXER CAPACITY ½ CUBIC YARD

Actual amount air required	Length of horizontal discharge					
	100	300	400	600	800	1,000
Cu. ft. of free air per minute.	Lin. ft.	Lin. ft.	Lin. ft.	Lin. ft.	Lin. ft.	Lin. ft.
600	20	15	10	..	..	..
800	30	20	18	12	6	..
1,200	40	30	25	20	12	8



SULLIVAN WJ3 ANGLE-COMPOUND COMPRESSOR THAT SUPPLIED AIR FOR CONCRETING THE VAN BUREN STREET TUNNEL.

Toll Gates on Country Roads

Virginia cities, like those in Indiana, are not taxed for country roads, but, unlike Indiana cities, they may contribute to the construction of roads to a distance of ten miles. Fredericksburg did not contribute to the cost of the roads in Spotsylvania county and its automobile traffic is wearing the roads. The county has established toll gates on these principal roads so that the traffic wearing the roads pays for their repair. This reversion to an ancient system seems to be a backward step, but if it results in a change in the law so that the cities originating the traffic can contribute their share toward the construction and maintenance of the roads carrying it, it will be thoroly justified. The Virginia legislature seems to be as difficult to lead into the march of progress as that of Indiana, which is one of the very few states not yet provided with a state highway commission and a method of building roads which will insure that they are of the same design and quality of construction in any two townships, or will even make the improved roads of adjoining townships join.

MISCELLANEOUS

Meetings of Organizations

February 5-9, in Mechanics Hall, Boston, Mass. American Road Builders' Association. E. L. Powers, secretary, 150 Nassau street, Boston, Mass.

February 6, 7, at New York. National Lime Manufacturers' Association. F. K. Irvine, secretary, 537 South Dearborn street, Chicago, Ill.

February 7-9, in Engineers' Building, New York City. American Institute of Electrical Engineers. F. J. Hutchinson, secretary, 33 West 39th street, New York.

February 7-9, at Hotel Radisson, Minneapolis, Minn. Minnesota Surveyors' and Engineers' Society. W. F. Rosenwald, secretary, Germania Building, St. Paul, Minn.

February 7-15, at the Coliseum, Chicago, Ill. Tenth Chicago Cement Show. Cement Products Exhibition Co., 210 South LaSalle street, Chicago, Ill.

February, dates as follows: At Providence, R. I., Engineering Society. February 7, structural engineering section on mixing and pouring concrete; February 9, industrial and technical education section; February 13, designing and drafting section; February 28, general meeting, addressed by Dr. M. R. Hutchinson, engineering adviser to T. A. Edison.

February 8-10, at Hotel LaSalle, Chicago, Ill. American Association of Engineers. Secretary, 29 South LaSalle street, Chicago, Ill.

February 8-10, at Hotel LaSalle, Chicago, Ill. American Concrete Institute. H. D. Hynds, secretary, 1418 Walnut street, Philadelphia, Pa.

February 9, at Sherman, Tex. Texas Town and City Planning Association. J. E. Suratt, secretary, Sherman, Tex.

February 12, 13, at Sherman Hotel, Chicago, Ill. National Builders' Supply Association. L. F. Desmond, secretary, 1211 Chamber of Commerce Building, Chicago, Ill.

February 12-14, at Chicago, Ill. American Concrete Pipe Association. E. S. Hanson, secretary, 538 South Clark street, Chicago, Ill.

February 14, 15, at Claypool Hotel, Indianapolis, Ind. Indiana Sanitary and Water Supply Association. W. F. King, secretary, State House, Indianapolis, Ind.

February 14-16, at Hotel Sherman, Chicago, Ill. Illinois Lumber and Builders' Supply Dealers.

February 15, 16, at Madison, Wis. Wisconsin Engineering Society. L. S. Smith, secretary, 939 University avenue, Madison, Wis.

February 19-22, at Engineering Building, New York City. American Institute of Mining Engineers. Bradley Stoughton, secretary, 29 West 39th street, New York City.

February 19-24, at the Convention Hall, Kansas City, Mo. Southwestern Concrete Association. Chas. A. Stevenson, 1413 West 10th street, Kansas City, Mo.

February 21-23, at Ames, Iowa. Iowa Engineering Society. J. H. Dunlap, secretary, Iowa City.

March 5, 6, at Hotel McAlpin, New York. National Paving Brick Manufacturers' Association. W. P. Blair, secretary, Cleveland, O.

March 5-7, at Hotel Astor, New York. American Ceramic Society. Edward Orton, secretary, Columbus, O.

March 5-11, at Grand Central Palace, New York. National Complete Building Exposition.

March 6-10, at Auditorium, Omaha, Neb. Mid-West Cement Show.

March 7-10, at Hotel Rome, Omaha, Neb. Mid-West Cement Users' Association.

May 8-10, at Washington, D. C. National Fire Protection Association. Franklin H. Wentworth, secretary, 87 Milk street, Boston, Mass.

May —, at Cincinnati, O. Dixie Highway Exposition and Convention.

June —, at St. Paul, Minn. International Jefferson Highway Association.

November 12-16, at Hotel Gruenewald, New Orleans, La. American Society of Municipal Improvements. Charles C. Brown, secretary, 608 South Dearborn street, Chicago, Ill.

How New York City Now Controls the Development of Private Property

By George B. Ford, Consultant to the Commission on Building Districts and Restrictions.

The city government of New York has just put into effect by a virtually unanimous vote of the Board of Estimate and Apportionment the radical and much-talked of Zoning Law. All future buildings will be restricted as to their height, size and use, and the restrictions will be different in different parts of the 327 square miles of the city.

Hon. George McAneny, the father of the law, said: "It is the greatest thing the city has ever done, not even excepting the building of the great rapid transit system." Mayor Mitchel said that he believed that it would prevent in the future the enormous decline in property values, such as had occurred below Thirty-fourth street in Manhattan. He believed that residence sections thruout the city would be protected against the sporadic store, factory or garage.

In general, the law will limit the height of buildings in proportion to the widths of the streets on which they face all the way from two and a half times the width of the street in the financial district, thru two times the width of the street in central Manhattan, with one and one-half times in the balance of Manhattan and in small portions of the other boros, down to once the width of the street thruout all the rest of the city. A future Equitable building could only be a third as high, because it faces on narrow streets, but a tower in the center of it, half as large again as the Woolworth tower, might rise to any height. The Woolworth build-

ing on the other hand, if facing on a park, might be very nearly duplicated. The shopping district of Fifth avenue will consist of buildings not much higher than Tiffany's, but along Forty-second street buildings may rise about as high as the Hotel Manhattan or Knickerbocker. Twelve and 14-story apartments will continue to go up on the main avenues and eight and nine-story apartments on the side streets, but no building of any kind can go any higher except by setting back from the street. Thruout most of the city, however, four or five stories will be the limit. Towers may be built to any height, but they cannot cover more than a quarter of the lot. Mansards, dormers and terraces are encouraged; anything that will open the streets and bring light down into them by making the upper part of the buildings set back from the street above a reasonable height.

The size of buildings will be controlled by the fact that the law requires just so much open space on each lot. This again ranges all the way from the warehouse districts along the commercial water front and along the freight railways, where a building may cover the whole of its lot, thru the B, C and D districts, so-called, in each of which in succession a building has to provide for larger and larger yards and courts, down to the villa districts, where a house can cover only 30 per cent of its lot and must be widely separated from its neighbor on at least one side. Thruout Manhattan and the densely built-up portions of the other boros, yards and courts in office buildings, factories, lofts, hotels, apartments, in fact, all buildings, would have to be as large as those that have been required for the last 14 years in tenement and apartment houses. Everywhere the yards and courts have to be increasingly larger at the top as a building goes up in height, so much so that these requirements tend to limit the practicable economic height of buildings even more effectively than do those directly affecting height. This is particularly true in the outlying boros. One important feature of the law is the encouragement it gives to playgrounds, for material concessions are allowed to any one who will provide adequate recreational space in connection with his buildings.

Right here it is desirable to sound a note of warning. It would be most unfortunate if the law were applied as it stands to other cities, for it is full of unduly liberal provisions in the way of height and size that tend strongly to defeat the object of the law, but which were necessitated by the exceptional economic conditions of New York.

As to the use of buildings, there are only two general restrictions; first, the districts which are restricted against business and industry of all sorts, the so-called "residence" districts, and, second, the tracts which are restricted only against manufacturing and public stables and garages, the so-called "business" districts. In the former almost any kind of building that people live in is allowed, also churches, schools, hospitals and various institutional buildings. In the business districts any residence use is allowed, and even a certain small proportion of the unobjectionable types of manufacturing. The use districts have been laid down street by street, and, in fact, block by block, depending on existing conditions and tendencies. The result has been that about two-fifths of Manhattan and about two-thirds of the whole city has been set aside for all time for strictly residential use, while the main thorofares, the transit streets and all other streets that are or might be appropriately used for stores or show rooms are set aside as business streets. Many streets which are now seriously invaded by factories or garages are restricted against them from now on because it was felt that they were a distinct harm to the street. On this ground all of the central part of Manhattan above Twenty-third street was made a business district, despite the fact that there were already hundreds of factories, employing in all upward of 30,000 operatives, within the district. This law will not touch the existing factory lofts, as it is in no sense retroactive, but the "Saving New York" movement, in which most of the merchants along Fifth avenue combined to oust the factories in the neighborhood, has already succeeded in persuading almost all of the manufacturers to move away. It was a remarkable and timely vindication of the economic need of this law.

It is interesting to see how the unbroken residence districts have been becoming larger and larger at the insistence of the property owners themselves, so that in some cases of their own volition they must walk at least a mile to the nearest store of any sort. These restrictions do not interfere in any way with existing or future private restrictions placed on any property except that if this law happens to be more drastic than the latter in any particular this law would govern. All of the balance of the city which is not in one or the other of these two kinds of districts is left unrestricted. It includes all of the land appropriate for industry along the navigable water front and along the freight railways, as well as most of the territory which is now given over to manufacturing. It includes also scattered thruout the city a number of blocks which are already invaded by public garages or which are appropriate for that use. Certain other areas, especially around Jamaica Bay and along the shores of Staten Island, are left entirely undetermined in their use pending the working out of the plans for the port and terminal facilities of New York.

In the various reports of the Commission nothing whatever has been said about the effect of the new law on the appearance of the city, and yet within the next 25 or 50 years it is bound to make the city far more orderly and even more beautiful. It has been said that it would spoil the glorious sky line of New York and rob the city of its "crowning glories." But so far from doing that, I am convinced that the sky line of New York some 25 or 50 years from now will be far more wonderful than anything we have yet dreamed of, for the law is full of special provisions which are bound to encourage the erection of towers, mansards, dormers, terracing roofs of a variety and interest far different from anything which this country has yet seen. More immediately, it will put order and harmony into the streets of the city, particularly the residential streets. It will tend to prevent the streets from being broken up, as they are now.

High Prices Delay Chicago Bridge Plans

An increase in prices bid, amounting in some cases to 100 per cent. over estimates, has resulted in holding up the awarding of the contracts for the Twelfth street bridge in Chicago, so great an increase being termed extortionate. The city still has nine bridges to build with the $6,500,000 remaining of its bond issue for this purpose. Of the others, two are ready to advertise for bids, two have plans completed, one under way and the other four will follow other improvements which are not yet ready for the bridges.

Prizes for Engineering Papers

The prizes for engineering papers by undergraduates and recent graduates of technical colleges, offered by the Engineers' Subdivision of the Chicago Association of Commerce, have been awarded. The first of $50 to Harvey T. Hill, Field Museum, Jackson Park, Chicago, subject, "Engineering and Civic Progress"; the second of $30 to Leo Shippy, 2903 West street, Ames, Iowa, and the third of $20 to H. M. Kistler, 6737 Penn avenue, Pittsburg, Pa., subject of each, "The Engineer of the Future." Honorable mention was given to R. D. Stitt, 72 West Adams street, Chicago, subject, "The Business Relations of the Engineer to the Commercial World," and to Gordon D. Cooke, 160 Dexter boulevard, Detroit, Mich., subject, "Charting Rocks and Reefs on the Great Lakes."

Technical Schools

A recent publication of the Engineering Experimental Station, University of Illinois, Urbana, Ill., is entitled "Subsidence Resulting from Mining." Bulletin 91, 200 pp., paper, free.

Bulletin No. 10 of the research division of the electrical engineering department of the Massachusetts Institute of Technology is by A. E. Kennelly and O. R. Schurig and gives a discussion of a series of experiments on traction resistances to a motor delivery wagon on different roads and at different speeds.

Civil Service Examinations

The U. S. Civil Service Commission will hold examinations at the usual places as follows:

At any time papers are presented: For mechanical draftsman, office of chief of ordnance, War Department, Washington, D. C., at $1,000 to $1,200.

February 6: Electrical draftsman in bureau of yards and docks, Navy Department, at $3.52 to $6 a day; mechanical draftsman, same office and pay.

February 7: Laboratorian qualified in electrical science in machinery division of Mare Island navy yard, Cal., at $3.60 a day; sanitary engineer in Philippine health service, at $1,600 a year; second-class steam engineer, State, War and Navy Department Building, Washington, D. C., at $1,000 a year; junior physicist in bureau of mines, Pittsburg, Pa., at $1,500 a year; electrical assistant in signal service at large, War Department, at $1,200 a year.

February 7-8: Laboratory assistant in bureau of standards, Department of Commerce, at $900 to $1,200; mechanical laboratorian in naval engineering experimental station, Annapolis, Md., at $4.24 a day; aid and deck officer in Coast and Geodetic Survey, at $1,000 and field allowances.

February 13: Marine draftsman, Panama Canal service, at $125 to $150 a month.

February 27: Sub-inspector of ordnance in any navy yard or establishment, at $4.48 a day.

February 27-28: Assistant engineer in forest products, at Madison, Wis., at $900 to $1,200 a year.

A Correction

Through error in make-up department our January issue reproduced a comparative cost record tabulation on page 63 of the Motor Truck Section. The statistics from which these records were compiled were obtained by our editorial department some time ago, and while the statistics were accurate at that time they are now out of date, inasmuch as the price of the 3-wheel type Martin tractor was $3,750, whereas the price of the 4-wheel Knox tractor at this time is $4,500. Consequently this change in prices seriously affects the data. The present type of Knox 4-wheel tractor is equipped with electric lighting and starting systems whereas the old 3-wheel model possessed none of these modern improvements and conveniences. Since the hauling tabulation was compiled, the cost of operating horse-drawn vehicles has materially increased and the comparisons recorded in the table therefore are not accurate under present conditions.

Personal Notes

Robert H. McCormick, for thirty-four years in the city engineer's office at Detroit, Mich., for the last sixteen years as chief, has resigned and is succeeded by Clarence W. Hubbell, formerly civil engineer for the Detroit Board of Water Commissioners and more recently in responsible positions in the public works department of Manila and the Philippine Islands.

Harry F. Harris, recently assistant engineer in charge of Trenton, N. J., street construction, has been appointed engineer of the county in which Trenton is situated.

E. S. Shuler is city manager of Sumter, S. C.

Henry Welles Durham has resigned as county engineer of Bergen county, N. J., to devote himself to his consulting engineering practice in connection with Percival Robert Moses, at 366 Fifth avenue, New York. Ross McClave is his successor as Bergen county engineer.

Francis J. Brennan has been appointed street commissioner for Boston, Mass.

Fuller and McClintock is now the style of the firm of George W. Fuller, consulting engineer, 170 Broadway, New York, and Jesse K. Giesey has been admitted as a partner.

George P. Bemis, who was quite as spectacular in his way as his cousin, George Francis Train, and was associated with him in the construction of the first tramways in London, England, recently died at the age of 78 years, in Omaha, Neb., of which city he was twice mayor. The two were active promoters of the Union Pacific railway; of a French republic in 1870, for which effort they barely escaped execution; of woman suffrage in its early and most strenuous days, and of other movements, progressive, spectacular, or both. Mr. Bemis celebrated his seventy-fifth birthday by a fifteen-day fast.

J. L. Stephens, for some years assistant city engineer, has been promoted to city engineer of Mishawaka, Ind.

Capt. J. H. Burnham, a well-known bridge contractor of central Illinois, died at Bloomington, Ill., January 21, at the age of 83. Beginning in 1867, he supplied half the counties of Illinois with iron bridges, following them with concrete bridges, many of which he has built during the last ten years.

Publications Received

The Institute for Public Service, W. H. Allen, director, 51 Chambers street, New York, issues a weekly bulletin, entitled "Public Service," under its public service exchange, the subscription price being 50 cents for 40 issues to 3 persons. Its mission is co-operative (1) with mayors and other municipal officers in keeping in touch with what other communities are doing; (2) with newspapers by means of short weekly articles on advances in city government; (3) sheets of short public service notes; (4) aid in answering questions asked by local readers or editors.

The Elgin Commercial Club, of Elgin, Ill., thru the liberality of certain citizens and printers, has issued a report on an Elgin city plan which demonstrates the progressive spirit of this small city. It will certainly make the city a beauty spot and set a pace which will ultimately surround Chicago with beautiful suburban cities and towns. It takes advantage of the possibilities in the surroundings and utilizes them at very reasonable cost.

C. E. Grunsky, of San Francisco, has written a valuable book on valuation of public utilities and other engineering structures, which is published by John Wiley & Sons at $4 net. It is a notable contribution to a subject on which many books have been written in the last five years or so.

A Handbook on Wood Preservation has been issued by the American Wood-Preservers' Association, F. J. Angier, secretary, Mt. Royal Station, Baltimore, Md., which gives very full information about processes, the history of the industry and the plants now in operation in the United States and Canada. It gives also the constitution and the list of members of the association in 1916.

Bulletin 388 from the U. S. Office of Public Roads gives public road mileage and revenues in the New England states in 1914.

Recent bulletins of the Portland Cement Association are on concreting in cold weather and concrete houses.

MACHINERY AND SUPPLIES

Williston Construction Co.'s Asphalt Plant

The steadily increasing popularity of the portable asphalt plant is most recently shown by the De Pere, Wis., installation of a Cummer type by the Williston Construction Company.

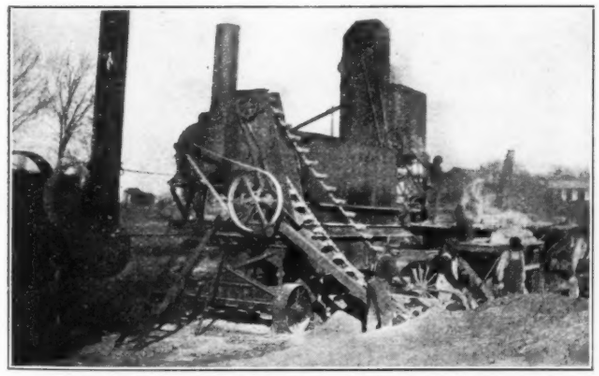
This well-known Chicago firm of paving and sewer contractors received a new Cummer 3-unit plant the latter part of September and commenced operations with it in De Pere on October 3, finally completing the work on November 11. The plant was not operated continuously during this period, delays being principally caused by failure of the street railway company to get their portion of the work ready in time. The contractor also had considerable wet weather with which to contend and only completed the job an hour or so before a snowfall that was 10 inches deep by next morning.

C. H. Draney, superintendent for the Williston Construction Company in De Pere, reports a total of 22,213 sq. yd. of 2-inch asphalt concrete laid on 5-inch concrete foundation, on the following streets: Charles street from Broadway to Huron, 4,395 sq. yd.; Michigan street from Fulton to Merrill, 8,710 sq. yd.; Third street from Lande to Main, 9,108 sq. yd.

"The Cummer plant we used," states Mr. Draney, "is rated at 1,800 square yards of 2-inch surface daily, and under favorable conditions we found it easily capable of turning out 2,000 square yards in a 10-hour day.

"It may be interesting to know this Cummer 1,800-yard road plant consists of three units, all mounted on wheels and easily portable from place to place as convenience may suggest. The main and largest unit is that containing the dryer and mixer. Also there are two portable fire-melting kettles, each equipped with an asphalt pipe line which comprises the second unit. The third unit consists of a portable boiler and engine.

"The mixer and dryer unit—weighing about 22 tons—was shipped on a flat-car and was unloaded by jacking it up off the car, and supported by a cribbing of railroad ties and 12 by 12 timbers. When sufficiently clear, the car was pushed out from under the plant, which was itself then lowered to the ground and towed by a steam roller to the location where it was set up. The other two units were unloaded by means of block and fall in conjunction with a steam roller. The plant was set up alongside the railroad tracks. All paving materials received were thus easily unloaded from the cars to the ground and then shipped up to the cold link-belt elevator by team.



CUMMER ROAD ASPHALT PLANT IN SERVICE OF WILLISTON CONSTRUCTION CO., DEPERE, WIS.

LAYING ASPHALTIC CONCRETE ON THIRD STREET, DEPERE, WIS. WILLISTON CONSTRUCTION CO.

"This cold link-belt elevator is beside the Cummer type dryer which it feeds. The sand and stone, after being heated, are passed into the hot elevator and on up into the storage bin, over which is placed a revolving screen, divided into three different sizes. Thence the screened material drops into the storage bin, which is itself divided into three compartments, the contents of each of which are drawn off separately and weighed before being introduced into the mixer located directly beneath. The foregoing applies to our manufacture of asphalt concrete, but the only alteration requisite for making sheet asphalt is in connection with the revolving screen.

"The mixer is of the twin pug type of 9 cubic feet capacity. It sits directly under the box in which the hot sand and stone is weighed. The latter is thence passed on into the mixer by merely lifting a lever which opens a gate. Limestone, dust, or other powdered material is then introduced into the mixer, after which asphalt cement—same having previously been pumped from the kettle to a bucket supported on a scale—is poured into the mixer. Then after having been thoroly mixed, the whole mass is emptied into the motor truck or wagon beneath. This is accomplished by simply moving a lever which opens a gate in the bottom of the mixer.

"The asphalt is melted in the kettles by direct fire and is transported to the mixer thru a steam-jacketed pipe line by means of a Kinney pump. Change can be made from one kettle to another by merely turning two stop cocks. The pump

works continuously during mixing, and the asphalt is kept in steady circulation.

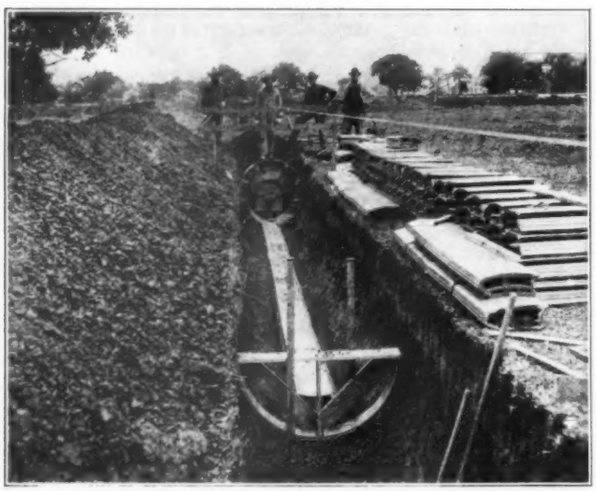
"We used Aztec asphalt, a portion of which was shipped in tank cars, and the remainder in iron drums. The tank cars were unloaded by means of a Kinney pump and the steam was afforded by the plant boiler. When finally mixed, the material was delivered in dump wagons to the streets where paving was in progress.

"Our plant crew consisted of a foreman, an engineer, a night-man, a drum fireman, a kettle man and a box-man. In addition to those we also employed two men feeding the elevator and about four other men for general work such as charging the kettles, etc.

"Our street paving crew included a foreman, a roller-man, three rakers, two tampers and six shovelers, beside the four men whose business it was to put on the flush coat and chips. Our roller is a Kelly-Springfield and weighs eight tons."

Vitrified Block Sewer

The accompanying photograph shows the end of a 30-inch single ring vitrified block sewer under construction in Fond du Lac, Wis., in a part of the line where the depth of trench is hardly greater than the diameter of the sewer. It is apparent that the street in which the sewer is laid will be filled to the elevation of the streets and tracks seen in the background and at the left, so that the sewer will have an ordinary amount of earth between it and the passing traffic. This really makes but little difference, however, as tests show that the block sewer will carry without side support above its horizontal diameter a weight far greater than would come on it from any road traffic.



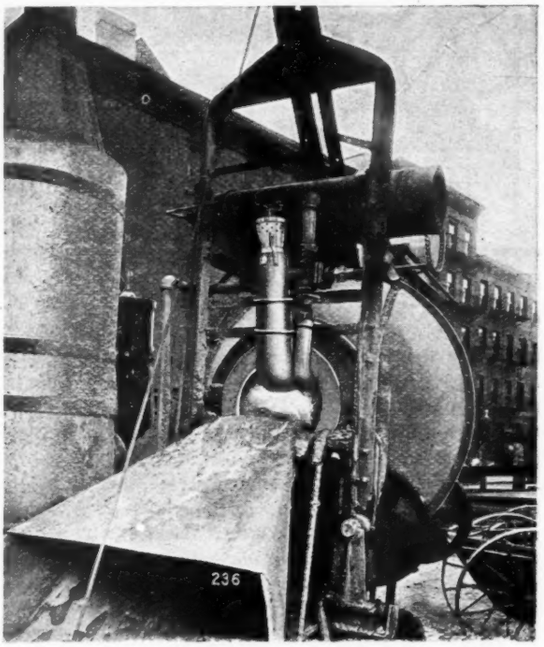
SHOWING ALL STEPS IN PROCESS OF LAYING SEGMENTAL BLOCK SEWER FROM TRENCH FORMATION TO BACK FILLING.

The photograph, for which we are indebted to the National Fireproofing Co., shows the shaping of the bottom of the trench to the shape of the sewer, the placing of the templet to whose form the blocks are laid, the invert block in place, with string stretched between form and completed sewer to give line and grade. The corrugated joint surface will be plastered with cement and the successive sections laid so as to break joint.

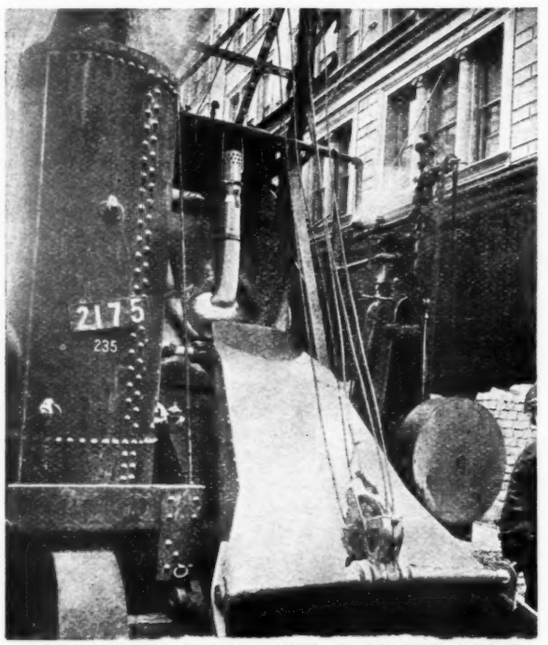
The end of the collapsible center on which the arch sections are laid is quite clearly shown, so that all the steps in the process of laying the blocks from trench digging to backfilling can be worked out from the one picture.

An Oil Burning Heater for Concrete Mixer

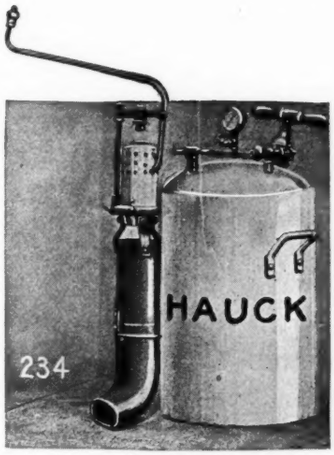
The accompanying photographs almost tell the story of the Hauck compressed-air oil burner for heating concrete mixers in cold weather. The small cut shows the elements of the apparatus, the tank, the hand pump for putting on the operating air-pressure of 20 to 60 pounds per square inch, the vaporizer, burner and heating pipe. A few minutes' operation of the hand air pump will keep the pressure within the limits named for three hours of operation. The burner is of the vap-



HALF YARD FOOTE CONCRETE MIXER EQUIPPED WITH HAUCK COMPRESSED AIR OIL BURNER. RAPID TRANSIT SUBWAY CONSTRUCTION CO., NEW YORK SUBWAY.



HALF YARD MILWAUKEE CONCRETE MIXER OPERATING WITH HAUCK HAND PUMP KEROSENE HEATER. NEW YORK SUBWAY CONSTRUCTION.



HAUCK KEROSENE HEATER HAND PUMP BUILT INSIDE TANK FOR FORCING OIL TO BURNER.

orizing type, burning kerosene or coal oil and is subject to a special patent.

One of the larger photographs shows a Foote mixer equipped with the heater and another shows it on a Milwaukee mixer. The connections, locations of oil tanks and burners show for themselves as conveniently out-of-the-way of the concrete-mixing operations but readily reached for what little attention they may need. Further information can be obtained from the Hauck Manufacturing Co., 140 Livingston street, Brooklyn, N. Y.

Forms in Sidewalk Construction

By J. S. Murray, Contractor, New Kensington, Pa.

The one-course concrete sidewalk, as compared with the two-course type, is rapidly gaining in favor as the entire mass is wearing surface. One layer naturally can be placed more cheaply than two, and the additional strength is such that the equivalent of a 5-inch two-course walk can probably be obtained by 4½ inches of the richer mix, placed in one operation.

Then, too, the actual amount of materials is nearly identical for each type. Below is shown the comparison of the two constructions based on 100 square feet of surface:

Type	Mixture	Bbls. Cement	Cu. Yds. Sand	Cu. Yds. Gravel	Total Cost Materials
5-inch 2-course....	1:2½:5 base				
	1:1½ top	2.52	.80	1.21	$6.79
4½-inch 1-course..	1:2:3	2.42	.73	1.08	6.16

The cost of cement walk, of course, will vary with the cost of materials and labor and with the experience of the men doing the work; also with the location of the walk, the amount of walk to be placed at one time and its width, as well as the types of forms used.

Our experience has been that the proper use of steel forms is a most important factor in the reduction of construction cost, as less manual labor is required and the work progresses in more speedy and uniform fashion. In our work, we use 200 feet of Heltzel sidewalk forms as well as 325 feet of curb and gutter forms.

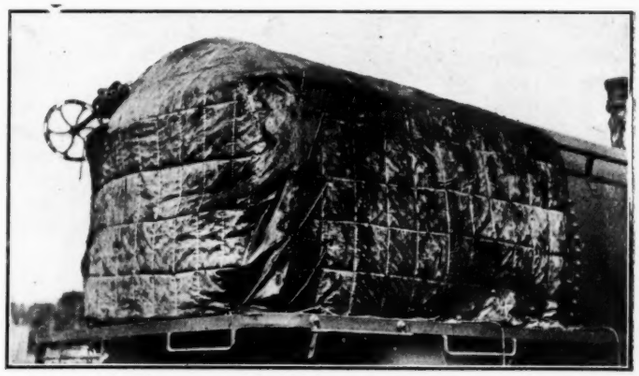
The recommended method of constructing sidewalks with these forms is about as follows: At least 50 feet of forms are connected up in place and the concrete placed in the first block. The grader starts at work leveling the concrete so that after it is tamped it will come within 1 or 1½ inches of the top of the forms. Behind the grader follows the tamper, tamping the whole concrete surface firmly, taking pains to tamp next to the side rails and the division plates. The concrete should have been mixed middling stiff. While this work is being done another part of the gang should have been mixing the top. This, too, should be mixed middling stiff, with just enough water so that when it is tamped firmly into the concrete base there will be enough moisture come to the top to finish nicely. There is another tamper at work on the top. Following him are two men striking off, and close on the strike-off is the finisher floating and edging, which is also done immediately without any waiting for the puddled surface to dry out.

The sidewalk forms are composed of rigid, adjustable, flexible and curved side rails; also division plates or templates. The rigid side rails are made of annealed steel, pressed to shape in sections of 6, 9 and 12-foot lengths, with curvilinear openings in the top flange to receive the division plates at intervals of one foot. These rails are 4 inches deep with a 1½-inch flange on the bottom and a 2-inch flange on top, from which is a depending flange of 1 inch, and are connected end to end by sleeves. Rigid adjustable side rails, 5 feet long are arranged to telescope a part of their full length with the regular side rails. By their use, forms can be set in any odd space without using any wood to fill in. Flexible side rails made in 6, 8, 10 and 12-foot lengths, slotted at intervals of 1 foot for division plates are used in curved sections.

Reduces Time in Unloading

The application of heat is necessary in unloading a tank car of asphalt. It takes a few hours to raise a full head of steam in the coils and to begin to affect the solidity of the asphaltic material. In fact, approximately 24 hours generally has been found necessary to unload the average tank car in severe weather. Any reduction of this time tends to greater efficiency, as it might save demurrage, and would certainly reduce the expense of fuel and attendants.

A portable cover has been invented for the purpose of reducing the amount of heat lost by radiation while heating the tank. By the use of this cover it has been found that the



INSULATING COVER PARTLY IN PLACE ON ASPHALT TANK CAR.

time of unloading a car in severe weather is reduced about one-half. The cover, furnished by the H. W. Johns-Manville Co., is in blanket form and is equipped with lashing ropes and grommets for the purpose of making it fast to the running board, and also with grommets and lacing rope so that the sections may be laced together, avoiding the possibility of the cover being blown away by the wind.

The stitching in both directions makes it impossible for the asbestos insulating material to wad in the canvas. The manufacturers use 8-oz. canvas next to the shell of the tank, and 7-oz. canvas, paraffin treated, on the outside. The covers are being manufactured for 6,500, 8,000 and 10,000-gallon tank cars. The present price of the 6,500-gallon cover is about $260, and of the 8,000-gallon cover, about $300, f. o. b. New York. The accompanying illustration (shown through the courtesy of the *Canadian Engineer*) shows one section of the cover in place on a tank car.

Midget Electric Pump for Draining Cellar Seepage

Residences located on low ground are perpetually subject to the seepage of water in their cellars and the condition is not easily remedied for the reason that not even concrete floors and walls are successful in preventing the gradual entrance of water.

To eliminate this condition a new electric seepage pump has been invented which, according to all reports, is proving remarkably efficient. For the best use of this pump a hole for use as a small reservoir should be made in some corner of the cellar. The water will then naturally seep into that instead of working its insidious way up thru the concrete of the floor. This tank hole, being at a lower level than surrounding floor, insures the dry, sanitary condition of the rest of the basement.

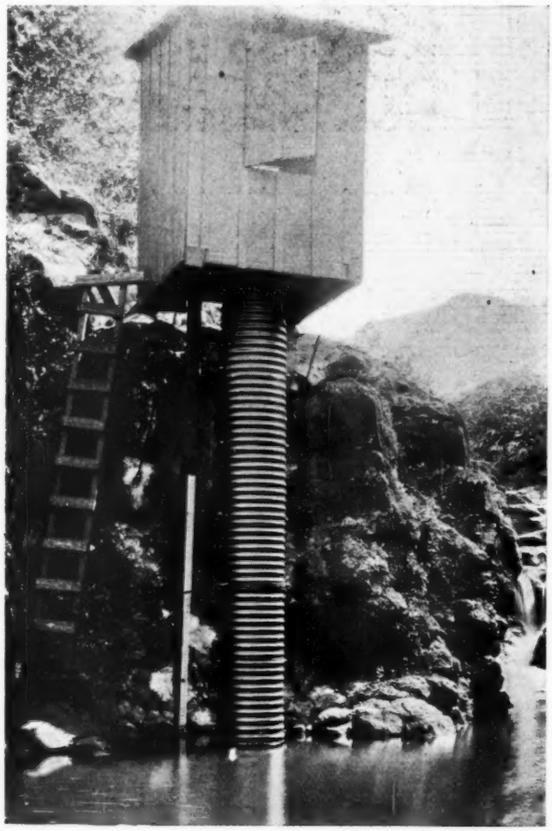
The pump device is equipped with a vertical-shaft motor which is located on the cellar floor at the edge of the tank hole. The shaft is connected with a small centrifugal pump submerged in the water in the hole. Operation is entirely automatic. A float sets the motor going immediately the water has attained a fixed height and shuts off the current as soon as a sufficient amount has been pumped out.

THE MOTOR HAS A VERTICAL SHAFT CONNECTED WITH A CENTRIFUGAL PUMP UNDER THE WATER IN THE HOLE BENEATH THE FLOOR.

(Courtesy of Popular Science Mo.)

Stream Gaging Station

The accompanying photograph shows a novel stream gaging ing station constructed and maintained by the U. S. Geological Survey, under C. T. Bailey. The float, counter-weight and



driving weight of the recording mechanism operate in the well, which is made up of sections of Armco iron corrugated culvert. The recording drum is in the house built around its top.

Dangers of Narrow Roads

Not long ago the photographer who was taking the moving pictures for the new Du Pont road-building film had set up his camera with a view of showing a short section of a narrow, rocky road. At that moment along came a boy pushing a bicycle followed by two men in a buggy. The horse became frightened and in endeavoring to turn out for the boy ran over a large boulder, tipping both men out and breaking the buggy.

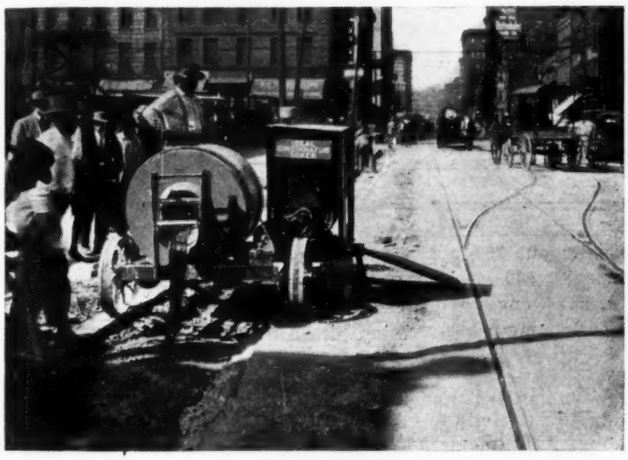
The photographer, being a true movie man, seized the opportunity to run the film on a "scene." Fortunately, no one was hurt, and the film was such a good illustration of the results of bad roads that it was incorporated into the body of the road-building film.

The Du Pont Company has made this film with a view of loaning it to responsible parties for showing at meetings of all kinds having for their object the aiding of good roads.

Direct Placing of Mix in Pavement Cut

We are illustrating a type of concrete mixer as used by the city of Cincinnati which deposits the concrete mix directly into the pavement cut.

Considerable shoveling and cleaning of concrete was done away with thru this method of discharging directly into the trench. This method considerably facilitated the work and the mixer was moved along over a trench about ten feet deep.

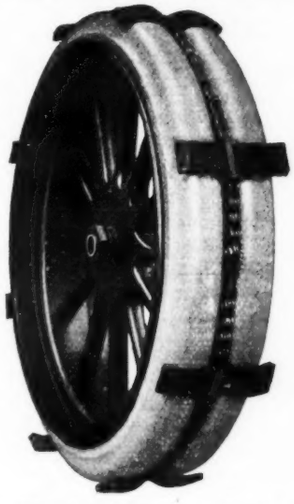


CONCRETE MIXER DISCHARGING DIRECT INTO PAVEMENT CUT.

Above method was adopted in filling in about five miles of pavement cut, which cut was necessitated on account of installing as many miles of pressure water mains in the business district.

An Anti-Skidding Device

We are illustrating an attachment that is designed especially for use with trucks having dual tire equipment. This consists primarily of a chain that encircles the wheel circumferentially between the shoes of the dual tire, which at intervals carries a series of cross pieces that are mounted at right angles to the chain.



These cross pieces are constructed of woven steel wire of finest quality, so that they are practically unbreakable, save thru wear, and have comparatively large areas in contact with snow or ice. The ends of these cross pieces cross the treads of the shoes and are of such width that they cannot damage the tires. The chains are fitted with turnbuckles to adjust them in the event of tires wearing. The chains can be put on without jacking the wheels and are easily attached with special tools. They are made for different sizes and makes of tires.

Safety Trench Braces

The Bond safety trench braces are made with double-thread steel screws so that they can be opened quickly to fit the width of trench. The steel nut, or handle, is drop-forged. Each head has a lug which can be placed on top of horizontal braces and prevents dropping into the trench so that one man can place any brace not too heavy for him to lift, as he can rest one end on a ranger while he is adjusting the length of the brace to the width of the trench.

Motor Truck Service at Reasonable Cost.

R. E. Taylor, president of the R. E. Taylor Corporation, 1457 Broadway, New York, announces his new plan of co-operation in truck service, whereby owners of the trucks he sells will receive a dividend at the end of the year if they have been charged during the year more than the cost of the service, repairs, renewals, supplies, etc.

This requires that he operate both the selling and the service departments in his territory, and the Gramm-Bernstein Motor Truck Company, of Lima, O., have agreed to co-operate with Mr. Taylor fully in his effort to give truck purchasers the kind and amount of service which they should have at actual cost. Mr. Taylor's organization guarantees this under his new plan of assuming responsibility for the service in his field.

Trade Publications

Under the title, "The Thames-Victoria Embankment Pavement," The Barber Asphalt Paving Company (Philadelphia) has just issued an illustrated pamphlet covering the history and evolution of the paving of London's famous thorofare. In 1906 the London county council undertook to replace the old water-bound macadam of the embankment with a more permanent wearing surface. Some ten or twelve types of pavement were laid. Starting with an initial area of only 800 square yards, Trinidad sheet asphalt has replaced all the other types of pavement and now covers the embankment from Blackfriars to Westminster bridge. A striking feature of the embankment pavement is the thickness of the binder course, namely 3 in. with a 1½-in. wearing surface. These proportions of course reverse the proportioning usually followed in this country. The first Trinidad pavement laid in 1906 was put down under the supervision and according to the ideas of Mr. Clifford Richardson, whose specification has not been changed in the pavement subsequently laid.

Dependable Concrete: Hydrated lime and its effect on workability, segregation, uniformity, strength, permeability, is published by the Hydrated Lime Bureau of the National Lime Manufacturers' Association, Arrott Bldg., Pittsburg, Pa., in Bulletin A-2.

A booklet on "Concrete Swimming and Wading Pools and How to Build Them" has been published and will be sent on request by the Portland Cement Association, 111 West Washington street, Chicago, Ill. Other booklets obtainable in like manner are "Concrete Linings for Irrigation Canals," "Concrete Sewers," and "Concreting in Winter."

The specifications for creosoted wood paving blocks adopted by the Asso. for Standardizing Paving Specifications are issued in pamphlet form by Robert W. Hunt & Co., engineers, Chicago, Ill.

The E. I. du Pont de Nemours & Company, of Wilmington, Del., have just had printed a Clay Blasting Booklet. As it is the first booklet ever issued on this subject, it contains valuable and interesting information. Some of the phases covered are "Digging Clay," "Stripping," "Blasting Down Shale," "Digging Plastic Clays," "Mining Flint Clays," "Draining Clay Pits," as well as full information on the use of explosives. The booklet will be sent to any address upon request.

FIRE DEPARTMENT

Advantages of Combination Pumper

EFFICIENT MOTORIZATION FOR THE SMALL TOWN AT A PRICE IT CAN AFFORD TO PAY.

By Chief Henry Smith, Lapeer, Mich.

The city of Lapeer, Mich., has in service its new South Bend Double Duty Hoosier pumper.

This pumping outfit, which was delivered in 30 days from date of sale, is rated at 350 gallons per minute, but shows a grand average of 500 gallons per minute. This type of motor-driven pumper is exceptionally light for its rated capacity, enabling the fire department of the small city to make greater speed over bad roads. The great majority of small pumps, now on the market, deliver small streams, but this outfit, moderate in size and weight, delivers a real fire stream. The pump, which is of improved geared rotary type, as perfected by A. C. Mecklenburg, of the South Bend Motor Car Works, is confined to a small area, yet sufficiently large and powerful to easily handle two 2½-inch fire streams at one time. This outfit, pumper and all, is confined in construction to the size of an ordinary, first-class combination chemical and hose wagon.

Results of Tests.

This outfit weighs 8,000 lb. over all, and aside from the pump, carries a 40-gal. chemical tank, 200 ft. of chemical hose, 20-ft. extension ladder, two 4-in. suction inlets, two 2½-in. quick-closing delivering gates and two 9-ft. lengths of 4-in. hard suction coupling with a strainer attachment. The tests were as follows:

Test No. 1—Two 2½-in. 300-ft. lines, siamesed to 1⅝ nozzle, 60 lb. at nozzle; capacity 600 gal. per min.

Test No. 2—One 300-ft. line, 2½-in., 1-in. nozzle tips 100 lb. at nozzle; capacity 465 gal. per min.

Test No. 3—One 300-ft. line, 2½-in., 1-in. nozzle tip, 80 lb. at nozzle; one 300-ft. line, 2½-in., or 1⅛-in. nozzle tip, 68 lb. at nozzle; capacity 560 gal. per min.

Test No. 4—One 300-ft. 2½-in. line, 1⅛-in. nozzle 63 lb. at nozzle; one 300-ft. 2½-in. line, 1⅛-in. nozzle 65 lbs. at nozzle; capacity 500 gal. per min. All above tests were made on a basis of one hour each, and the company states that the Hoosier pump has a rated capacity of 350 gal. per min.

SOUTH BEND "DOUBLE DUTY" HOOSIER PUMPER, AS OPERATED BY LAPEER, MICH.

Fire Department on Four Wheels.

The Hoosier pump, from which the entire outfit with a carrying capacity of 8 men derives its name, is operated by a 95-h.p. 4-cyl. motor. It is equipped with a Leece-Neville electric starter and generator and a 24-volt Willard storage battery.

This outfit, in spite of its limited size, is an entire fire department on four wheels. It is a pumper and at the same time it is a combination hose and chemical. It carries the men as well as the fundamental tools requisite to successful fire fighting.

Being a motor unit, it gets us to the fire in speedy fashion and while some of the men are busy in an endeavor to knock the fire with the chemical, thus preventing a head, others of the crew are making necessary pumper connections. No unit would get us to the fire quicker than this outfit, and successful fire-fighting depends on getting to the fire in time to strike it before it obtains a heavy start. If, however, the fire is a big one, we are there with our pumper and our entire department arrives at one and the same time. There are no delays, because we are there on four wheels.

Within Means of Small City.

But aside from the concentrated efficiency advantages of such a combination unit, we secure same at a price the small town can afford to pay. Our money is not invested in an overly large and heavy unit with a pumper of capacity exceeding our requirements, neither have we an unwieldly, bulky unit which would with difficulty navigate the muddy, rutty or hilly roads of the average town. The road conditions of country towns differ from the paved streets and boulevards of the large cities.

Many towns and small cities have unwisely spent their appropriations for units of greater than the necessary capacity. Yet these expenditures are but indications of the rapidly increasing desire to motorize. Some towns with populations as low as 2,500 have been hit with the motor bug to such an extent that they have plunged to the extent of $10,500 for a large motor pumping unit, overly large and a mighty poor investment, a white elephant all around when you consider that the man who must pay the bill could have obtained as efficient protection for considerably less money thru the purchase of such a pumping combination as I have described.

Why should any city pay more than necessary to secure maximum fire-fighting efficiency? Our combination gives the required efficiency for the smallest city at the right price and

it is also in line with the tendency toward a large number of moderate-sized units for use in the larger cities. The tendency in the purchase of motor apparatus in the larger cities is along these lines.

Small motor-driven units in every fire house and more fire houses—increased efficiency at lower cost. Fire stations should be more closely placed. It is good business to purchase two units where these units are to be had at the same cost as one large unit—two-fold efficiency at no increase in cost.

The outlying districts and the suburban tracts are demanding more protection. Vast districts in factory sections which now must rely on center or downtown motor apparatus, are demanding motor fire apparatus. A big fire in an outlying district means that the heavy apparatus located in the downtown district must make a long and expensive run. In such cases the apparatus in each zone must make a move toward the central zone; thus not only leaving the central, or downtown district under the protection of the second and third zones, but causing a tremendous expense in the moving of the apparatus from zone to zone. Fully 85 per cent. of our largest fires would never have happened if the fire could have been killed in its incipiency. In other words, real fire-fighting efficiency depends on getting to the fire quickly and knocking it before it gets a head. The greater the number of units properly distributed over a given area the more efficient does the fire-fighting become.

Horses are becoming more and more costly, but even tho they could be obtained at half their present price, they would still be costly as compared with the annual operating and maintenance of a moderate-sized pumping combination.

Massachusetts Municipal Electric Plants Show Important Gains

The Concord plant, about which a recent agitation for the abandonment of the local generating station in favor of purchased power resulted in the decision to continue to operate the plant, made a good showing, especially in the lighting load which includes small domestic appliances and electric ranges, of which there is a comparatively large number in that town. Two new industrial plants, which will take a considerable amount of power, will help the "curve" and improve the day load, of which there has been comparatively little heretofore. Improvements in the plant now going forward, which include a new feed water supply to the generating station, will help the plant's efficiency. The profit balance of nearly $7,000, obtained under the management of A. W. Lee, is a creditable feature of the year's operation.

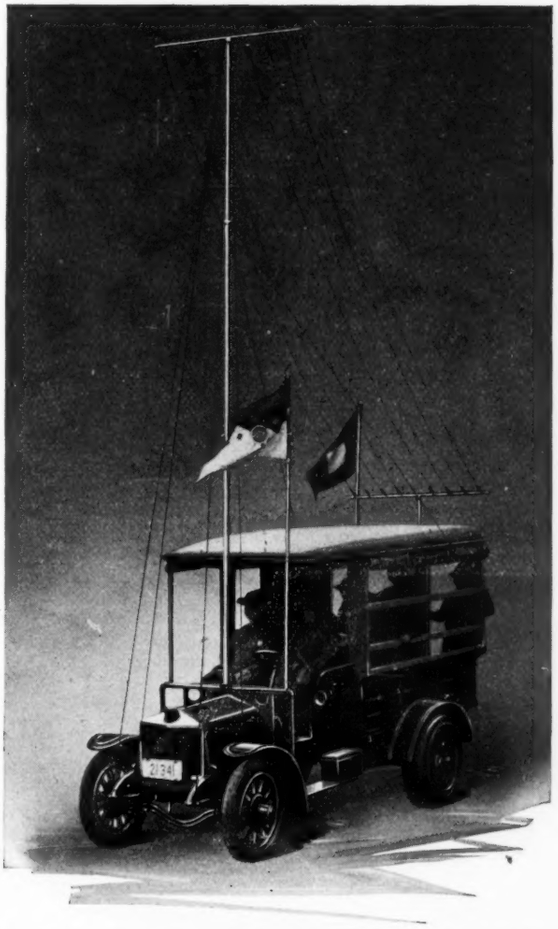
Peabody's gain, under the successful management of Warren D. King, is not less noteworthy, a profit of $15,000 on $71,000 of business being the record for the year. The town's plant generated 45 per cent more energy than the year before, the power load increasing more than 50 per cent, or 644 horsepower.

One of the most conspicuous increases in output and income is in the case of the Chicopee plant, which increased its kilowatt-hour output more than 75 per cent, and its gross income in the same ratio. This is a record hardly exceeded by any plant in the state in any year. Tho the return is incomplete in the item of connected loads, it is probable that the great increase in volume of electricity generated found use, in large part, in the power end of the business, the phenomenal increases in industrial activity, especially in Connecticut valley cities, accounting for great demands for this class of service.

Especially noteworthy, too, is the rise in figures representing the business of the Holyoke city electricity department. Here the gain in kilowatt-hour output was more than four million units, or nearly 35 per cent. Gross income increased more than $100,000 over the previous year, or 36 per cent, while operating expenses show an increase of only 12 per cent. A net profit from operation of $190,576 is shown as a result of the business of the year. The power business of the Holyoke plant gained 24 per cent in connected load, and when it is considered that the large power units, above 300 horsepower, are supplied by the Holyoke Water Power Company thru its generating department, the gain of 1,537 horsepower in the city is very commendable.

Hurlburt In Police Service

Herewith is shown a Hurlburt motor truck equipped with wireless outfit and used for transportation of supplies, strike work, riots and like emergencies by the New York city police department. It recently completed a trip to the Syracuse State Fair accompanied by forty of the mounted police flying squadron. These men were constantly in touch with their headquarters thru their wireless truck.



In the recent police parade, this truck led the parade and sent messages and orders to and from headquarters.

The New York police department selected this Hurlburt chassis after competitive tests of various machines. It is equipped with solid tires in the rear and pneumatic tires in the front and makes the second Hurlburt now in the service of the local police department.

Motor Apparatus in Fire Departments

(Continued from January number, page 25.)

In the second column of this table, in describing combinations, *ae* stands for aerial ladder equipment; *ch*, chemical; *chf*, chief's car; *ho*, hose; *h.p.*, high pressure; *L*, electric; *l*, ladders carried on combination trucks; *ladd*, city service hook and ladder equipment; *mot*, motorcycle; *pp*, gasoline pumping engine truck; *sal*, salvage corps truck; *sq*, squad wagon; *st*, steam pumping engine; *sup*, supply wagon; *tow*, water tower; *tr*, tractor; *tr. ae*, aerial ladder truck hauled by tractor; *tr. la*, hook and ladder truck hauled by tractor; *tr. st*, steamer hauled by tractor; *tur*, turret. *o* in column of "Years service" means that apparatus is new or not yet in service. *p*, pyrene cylinders.

1—Cost of gasoline and repairs. 2—Cost of gasoline, oil and tires. 3—55 gallons gasoline, 3 gallons oil. 4—180 gallons gasoline, 10 gallons oil. 5—40 gallons gasoline, 2 gallons oil. 6—105 gallons gasoline, 4 gallons oil. 7—Difference in cost of repairs in the two machines due to pneumatic tires on one and Dayton airless on the other. Both cars now equipped with Dayton airless. 8—Cost of repairs and gasoline and oil. 9—Materials only; repair work done by drivers or mechanicians in fire department. 10—Cost of repairs for all 28 machines in the department. 11—Cost per horse employed in the department. 12—6 gallons. 13—Sum for four American-La France pumping and combination. 14—These cost figures include all three pieces of apparatus and the cost of gasoline and oil includes also some police apparatus. 15—10 miles of streets in good condition, 5 fair, 15 bad. 16—gallons of gasoline. 17—542 gallons gasoline. 30 gallons oil. 18—121 gallons gasoline, 20 quarts oil. 19—214 gallons gasoline, 75 quarts oil; 20—25 per cent good, 40 per cent. fair, 35 per cent. bad. 21—40 per cent. good, 40 per cent. fair, 20 per cent. bad. 22—Two-thirds good, one-third fair.

	Kind	Maker	Years Service	Cyl.	H.p.	Ft. Hose Carried	Gal. Chem. Carried	Ft. Ladder Carried	Mi. Trav. Last 12 Mo.	Alarms Last 12 Mo.	Cost of Repairs Last 12 Mo.	Cost Gas. and Oil Last 12 Mo.	Cost Maintenance Same Horse Equip.
Minnesota—													
Minneapolis	chf	Buick (3)	½	..	...	....	...	...	....	....	.....	.....	.....
	chf	Ford	2	4	22	....	...	...	8,814	....	123.55	110.46	.....
	chf	Winton	2	6	49	....	...	...	8,336	....	63.17	214.90	.....
	chf	Cole	4	4	32	....	...	...	7,143	....	563.12	122.58	.....
	chf	Cole	4	4	32	....	...	...	3,083	....	680.87	73.21	.....
	chf	Cole	4	4	32	....	...	...	4,474	....	213.88	98.22	.....
	chf	Rambler	5	4	40	....	...	...	4,261	....	665.58	115.26	.....
	chf	Stod.-Dayton	5	4	40	....	...	...	3,566	....	674.36	113.61	.....
	ch ho	Four wh. drive	1	6	66	1,000	...	32	368	....	450.21	83.98	.....
	ch ho	Wilcox-local	4	4	29	1,000	50	32	569	....	127.92	32.72	.....
	sq ch	Am.-La France	4	4	48	....	50	32	1,419	....	107.24	88.63	.....
	ch ho	Am.-La France	5	4	48	1,200	50	32	494	....	146.53	53.85	.....
	ch ho	Am.-La F. (2)	o	6	100	1,200	6	32	....	....	.....	.....	.....
	sq	Am.-La France	o	..	...	....	...	...	....	....	.....	.....	.....
	tr	Am.-La France	o	6	75	....	...	...	....	....	.....	.....	.....
	sq	Am.-La France	½	6	100	....	...	...	....	....	.....	.....	.....
	tr	Nott	2	6	80	....	...	...	411	....	278.88	73.35	.....
	tr	Nott	3	4	44	....	...	...	680	....	140.22	59.37	.....
	ae	Seagrave	1	6	80	....	...	85	305	....	107.81	32.88	.....
	ch ho	Seagrave	4	6	80	1,000	50	32	423	....	845.29	57.34	.....
	ch ho	Seagrave	4	6	80	1,000	50	32	452	....	37.89	44.83	.....
	ch ho	Seagrave	4	6	80	1,000	50	32	285	....	429.93	45.51	.....
	pp ch ho	Seagrave	1	6	80	1,000	30	42	400	....	292.22	55.81	.....
	pp ch ho	Seagrave	1	6	80	1,000	30	42	217	....	103.80	22.45	.....
	pp ch ho	Nott	2	6	104	1,000	...	32	508	....	284.07	136.21	.....
	pp ch ho	Nott	4	4	53	1,000	50	32	418	....	149.93	58.57	.....
St. Paul	chf	Pierce-A. (2)	6	6	36	....	...	...	....	....	.....	.....	.....
	sq	Pierce-A. (2)	4	6	66	....	40	...	2,834a	1,077a	.....	.....	.....
	ho	White	1-12	6	66	1,200	...	...	....	....	.....	.....	.....
	chf	Pierce-Arrow	8	4	45	....	...	...	....	....	.....	.....	.....
	chf	Cadillac	4	4	40	....	...	...	....	....	.....	.....	.....
	ch ho	Am.-La France	4	4	48	1,000	40	...	345	231	.....	.....	.....
	tr la	Am.-La F. (2)	1	6	80	....	...	308	161	212	.....	.....	.....
	tr st	Am.-La France	½	4	48	....	...	...	....	....	.....	.....	.....
	pp ch ho	Waterous (2)	4	4	90	....	...	...	430	157	.....	.....	.....
	tr la	Seagrave (2)	1	6	80	....	...	240	160	391	.....	.....	.....
	chf	Oakland (3)	2½	4	35	....	...	...	....	....	.....	.....	.....
	chf	Ford (2)	3	..	22	....	...	...	....	....	.....	.....	.....
	chf	Maxwell	6	..	30	....	...	...	....	....	.....	.....	.....
Winona	chf	Mitchell	1	6	48	200	31	...	2,500	100	5.00	60.00	225.00
	ch ho l	Seagrave	4	6	80	1,700	40	36	100	65	15.00	30.00	400.00
	ch ho l	G. M. C.	1	4	40	1,300	50	40	80	50	o	15.00	400.00
Mississippi—													
Aberdeen	ch ho	Am.-La France	1	6	55	1,400	40	32	....	....	.....	.....	.....
Brookhaven	ch ho	Am.-La France	1	..	...	....	...	...	....	....	.....	.....	.....
Canton	ch ho	Am.-La France	1	6	55	1,400	40	32	....	....	.....	.....	.....
Clarksdale	pp ho	Am.-La France	1	6	100	1,200	6	32	....	....	.....	.....	.....
Greenville	pp ch ho	Am.-La France	1	4	75	1,200	45	40	239	80	33.68	34.45	240.00
	chf	Oakland	1	4	40	....	2½	...	2,955	141	0	45.85	120.00
Greenwood	ch ho	Am.-La France	4	4	70	1,400	35	32	....	....	.....	.....	.....
Granada	ch ho	Am.-La France	½	4	75	1,000	40	36	....	....	.....	.....	.....
Hattiesburg	pp ho	Am.-La France	2	6	100	1,200	6	32	....	....	.....	.....	.....
Jackson	pp ho	Am.-La France	2	6	100	1,200	6	32	....	....	.....	.....	.....
Laurel	ch ho	Am.-La France	2	4	70	1,400	35	32	....	....	.....	.....	.....
McComb	ch ho	Am.-La France	2	6	55	1,400	40	32	....	....	.....	.....	.....
Vicksburg	ch ho	Am.-La F.	2-3	4	75	1,000	40	36	220	157	0	59.77	241.90
	ladd	Am.-La F.	2-3	6	105	....	...	210	292	181	0	100.16	241.90
	chf	Overland	2	4	35	....	...	...	600	254	199.27	53.95	170.95
Missouri—													
Carthage	ch ho	Hale, Velie	3	4	65	1,200	40	48	200	64	28.00	32.00	350.00
Excelsior Springs	ch ho	Hale, Velie	..	..	...	....	...	...	....	....	.....	.....	.....
Hannibal		No motor apparatus. Present equipment all new horse-drawn.											
Joplin	pp ho	Am.-La France	½	..	...	....	...	...	....	....	.....	.....	.....
Kansas City	chf	Pope-Hartford	6½	4	40	....	...	...	10,950	380	359.45	182.65	288.41
	ch ho	Hale (12)	o	6	90	1,200	40	32	....	....	.....	.....	.....
	ho tur	Hale (2)	o	6	90	1,200	35	32	....	....	.....	.....	.....
	ladd	Hale (6)	o	..	...	....	...	...	....	....	.....	.....	.....
	ch ho l	Webb	5	6	90	800	40	32	2,150	449	884.11	197.80	830.69
	ch ho l	Hale	2	4	60	1,100	35	32	1,105	221	108.25	155.20	567.80
	pp ho	Webb	5	6	90	800	6	32	1,796	432	1,416.18	180.12	838.74
	tr	Knox	1	4	50	o	6	305	338	201	280.33	114.26	712.80
	tr	(3)	o	..	...	....	...	...	....	....	.....	.....	.....
Moberly	ch ho	Hale	1	..	...	1,300	42	273	273	81	0	23.28	.....
Monett	ch ho	Hale	..	..	...	....	...	...	....	....	.....	.....	.....
Poplar Bluff		No motor apparatus at present.											
St. Charles		No motor apparatus.											
St. Joseph	chf	Velie	5	4	40	....	6	...	....	....	.....	.....	.....
	chf	Cadillac	5	4	35	....	...	...	....	....	.....	.....	.....
	ch ho	Seagrave	2	4	50	1,000	46	72	....	....	.....	.....	.....

Tarvia
Preserves Roads
Prevents Dust

From the office of the Covert (Mich.) Township Board comes this letter, dated August 7, 1916:

I feel a great deal of satisfaction over the fact that your Mr. Clark persuaded us against our will to adopt "Tarvia-B" for a road preservative. The first mile of road built by us, owing to inexperience, poor equipment and the use of road oil, was deemed by us to be in a condition where it would have to be scarified and resurfaced. By the use of your "Tarvia-B" we now have it in a condition where, by its smoothness and solidity, it will give us good and continuous service. Our other road, built with more experience, better equipment and Tarvia, I believe is the equal of any stone road in the state. Our entire community are enthusiastic Tarvia fans. I can truthfully say our entire Township Board is ready at all times to recommend the use of your Tarvia products to any community looking for good, durable and smooth roads.

(Signed) ROBERT TRIPP,
Highway Commissioner,
Covert Township.

What happened in Covert

Read the Commissioner's Letter

WHAT was the magic argument which our representative used in this situation?

Just facts—cold facts.

Oil would lay the dust, but it frequently makes a peculiarly nasty road in wet weather. Oil would have no bonding power or road preservative value. On the contrary, its tendency would be to lubricate the road and interfere with the cementing power of water and stone-dust. Oil would not last as long as Tarvia, and therefore the apparent cheapness of oil was fictitious.

Many towns that once used oil have changed to Tarvia and stayed with Tarvia for years thereafter, because Tarvia was cheaper in the long run and very much better.

So Covert adopted Tarvia, and now has fine areas of tarviated macadam roads that are smooth, clean, durable, dustless and automobile-proof.

The citizens and the Highway Commissioners are proud of the way their town looks, and they have a right to be!

Write our Service Department for illustrated booklet and further information.

Special Service Department

This company has a corps of trained engineers and chemists who have given years of study to modern road problems.

The advice of these men may be had for the asking by anyone interested.

If you will write to the nearest office regarding road problems and conditions in your vicinity, the matter will have prompt attention.

The Barrett Company

New York Chicago Philadelphia Boston St. Louis Cleveland Cincinnati Pittsburgh Detroit
Birmingham Kansas City Minneapolis Nashville Salt Lake City Seattle Peoria
THE PATERSON MANUFACTURING COMPANY, Limited: Montreal Toronto Winnipeg Vancouver
St. John, N. B. Halifax, N. S. Sydney, N. S.

TRADE B MARK

Main Street, Covert, Michigan. Sixteen feet in center treated with "Tarvia-B."

West Michigan Pike, between Covert and South Haven Treated with "Tarvia-B."

	Kind	Maker	Years Service	Cyl.	H.p.	Ft. Hose Carried	Gal. Chem. Carried	Ft. Ladder Carried	Mi. Trav. Last 12 Mo.	Alarms Last 12 Mo.	Cost of Repairs Last 12 Mo.	Cost Gas. and Oil Last 12 Mo.	Cost Maintenance Same Horse Equip.
St. Louis	pp	Am.-La F. (2)	½	..	...	....	...	...	....	....	.....	.....	.....
	pp ho	Robinson (5)	1	..	...	1,000	12	16	....	....	.....	.....	.....
	tr	Robinson (2)	1	..	80	....	...	...	....	....	.....	.....	.....
	chf	Marmon	1	..	...	....	...	...	....	....	.....	.....	.....
	chf	Hudson	1	..	...	....	...	...	....	....	.....	.....	.....
	chf	Oakland (13)	1	..	...	....	...	...	....	....	.....	.....	.....
	pp ch ho	Robinson (3)	3	..	...	800	...	...	....	....	.....	.....	.....
	pp ch ho	Wagner	1	..	...	1,000	12	...	....	....	.....	.....	.....
	pp ch ho	Webb (2)	5	..	...	1,000	12	...	....	....	.....	.....	.....
	sup	(2)	..	..	...	....	...	...	....	....	.....	.....	.....
Sedalia	ch ho	Am.-La France	3	4	70	1,400	35	32	....	....	.....	.....	.....
Springfield	pp ho	Am.-La France	3	6	110	1,200	6	36	....	....	.....	.....	.....
	ch	Am.-La France	4	4	70	200	120	32	....	....	.....	.....	.....
	ho	Am.-La F. (2)	3	4	70	1,500	126	36	....	....	.....	.....	.....
	chf	Rambler	4	4	37	....	...	...	....	....	.....	.....	.....
	ch ho l	Anderson	3	6	70	1,500	35	36	....	....	.....	.....	.....
Trenton	pp ho ch	Buckeye	1-6	4	40	1,000	50	36	....	....	.....	.....	.....
Webb City	ch ho	Paige	2	4	36	500	10	...	100	60	60.00	15.00	.....
	ch ho l	Am.-La France	5	4	48	1,100	75	35	250	125	100.00	25.00	.....
Webster Groves	chf	Ford (2)	1-6	..	...	....	...	...	....	....	.....	7.00	.....
	ch ho	Am.-La France	1-6	..	70	1,200	35	30	150	7	0	8.00	.....
	pp ho ch	Howe Buckeye	1	..	80	1,000	35	30	600	72	175.00	42.50	.....
Montana—													
Anaconda	ch ho l	Webb	4½	6	70	1,200	90	40	....	....	.....	.....	.....
	ch ho l	Seagrave	1½	6	110	1,500	60	40	....	109	75.00	150.00	600.00
	pp	Am.-La France	½	..	...	....	...	...	....	....	.....	.....	.....
Billings	ch ho	Am.-La France	4	4	70	1,400	35	32	....	....	.....	.....	.....
Bozeman	chf	Ford	2	4	22	150	30	15	294	39	63.00	37.55	.....
	ch ho	Thomas	5	6	90	1,200	40	30	78	39	32.35	34.30	.....
Butte	ae	Couple Gear	4	4	60	....	...	85	....	....	.....	.....	.....
	pp ch ho	Am.-La France	½	6	100	1,400	40	32	....	....	.....	.....	.....
Forsyth	ch ho	Brockway	1	..	...	....	...	...	....	....	.....	.....	.....
Great Falls	ch ho	Am.-La France	2	6	100	1,400	40	32	....	....	.....	.....	.....
Kalispell	ch ho l	Nott	2	6	72	1,000	70	36	300	70	29.60	40.00	650.00
	pp ho l	Hale	2	6	78	1,000	6	36	200	10	22.80	41.78	.....
Lewiston	ch ho	Am.-La France	3	6	100	1,400	40	32	....	....	.....	.....	.....
Missoula	chf	Buick	3	4	4	....	...	...	....	....	.....	.....	.....
	ch ho	Seagrave	5	6	80	1,400	70	36	....	89	0	32.00	.....
	tr	Stevens-Duryea	2	6	70	800	10	...	....	18	0	22.00	.....
Red Lodge	ch ho	Am.-La France	1	..	...	....	...	...	....	....	.....	.....	.....
Nebraska—													
Columbus	ch ho l	Seagrave	5	4	53	1,250	70	50	35	22	25.00	.....	.....
Dundee	pp	Am.-La France	3	..	...	....	...	...	....	....	.....	.....	.....
Freemont	chf	Apperson	1	45	...	....	...	...	....	....	.....	.....	.....
	ch ho	White	2	45	900	50	...	...	40	....	.....	.....	.....
	ch ho	Nott	3	60	900	55	...	...	40	....	.....	.....	.....
Grand Island	ch ho l	Anderson	3	6	70	1,200	46	40	122	78	.....	64.46[a]	.....
Lincoln	ch ho	Am.-La F. (3)	5	4	70	1,400	35	32	....	....	.....	.....	.....
Nebraska City	ch ho l	Kissel	1	4	50	950	40	28	150	25	o	4.00	300.00
Norfolk	No motor apparatus as yet.												
Omaha	ho ch	Am.-La France	5-12	4	72	1,200	46	32	117	97	5.65	90.00	.....
	ho ch	Knox	4½	6	60	1,200	41	55	479	357	464.05	66.04	159.04
	ho ch	Am.-La France	1-3	4	72	1,000	46	32	123	93	4.51	42.68	.....
	ho ch	Am.-La France	¼	4	75	1,100	46	32	138	76	.....	29.58	.....
	ho ch pp	Am.-La France	¼	4	72	1,000	46	36	205	59	1.60	55.65	.....
	ho ch pp	Am.-La France	¼	4	72	1,000	46	32	307	20	152.03	45.81	.....
	ho ch pp	Am.-La France	¼	4	72	1,000	46	32	298	51	0.10	35.81	.....
	ho ch	Am.-La France	¼	4	72	1,200	46	32	227	56	1.96	46.74	.....
	ho ch	Am.-La France	1-3	4	72	1,000	50	33	120	66	.....	48.94	.....
	ho ch	Am.-La France	1-3	4	72	1,200	41	36	239	92	1.73	38.11	.....
	ho ch	Am.-La France	1-3	4	72	1,200	46	32	399	59	4.26	38.86	.....
	ho ch	Am.-La France	1-5	4	72	1,000	41	34	301	35	0	45.00	.....
	ho ch	Am.-La France	3	4	72	1,000	45	46	318	80	59.49	38.58	203.70
Superior	ch ho	Am.-La France	½	..	...	....	...	...	....	....	.....	.....	.....
Nevada—													
Reno	ch ho	(2)	o	..	...	....	...	...	....	....	.....	.....	.....
Sparks	pp ch ho	Am.-La France	½	..	...	....	...	...	....	....	.....	.....	.....
New Hampshire—													
Claremont	pp ch ho	Am.-La France	1	6	100	1,400	40	32	....	....	.....	.....	.....
Concord	ch ho	Robinson	3	..	80	1,000	80	50	....	....	.....	.....	.....
	ch ho	White (2)	2	..	30	1,000	40	50	....	....	.....	.....	.....
	ch ho	Winton	1	..	50	1,000	40	50	....	....	.....	.....	.....
	pp ho	Ahrens-Fox	o	6	100	1,000	6	32	....	....	.....	.....	.....
Derby	pp ho	Am.-La France	1	6	100	1,000	6	32	....	....	.....	.....	.....
Leconia	Has no motor apparatus at present.												
Manchester	chf	Cadillac	3	..	32	....	...	...	....	....	.....	.....	.....
	chf	Rambler	..	..	32	....	...	...	....	....	.....	.....	.....
	chf	Chalmers	½	..	25	....	...	...	....	....	.....	.....	.....
	ladd	Am.-La France	4	4	70	....	35	249	....	60	.....	.....	.....
	ch ho	Netco-Fed. (2)	2	..	...	....	...	...	....	....	.....	.....	.....
	ladd	Robinson	3	..	...	....	40	382	....	64	.....	.....	.....
Nashua	chf	Cadillac	1	8	80	....	...	...	700	190	32.00	33.00	.....
	sq	Maxwell	2	4	40	....	25	40	1,100	163	34.00	43.00	.....
	ch ho l	Seagrave	2	6	90	1,200	100	48	876	324	87.00	95.00	.....
Peterboro	ch ho	Am.-La France	2	4	70	1,400	35	32	....	....	.....	.....	.....
Plymouth	pp ch ho	Am.-La France	½	..	...	....	...	...	....	....	.....	.....	.....
Portsmouth	ch ho	Pope	4	4	50	1,000	70	40	300	92	54.00	20.00	.....
Rochester	ch ho	Am.-La France	½	..	...	....	...	...	....	....	.....	.....	.....
New Jersey—													
Atlantic City	tr	Am.-La F. (11)	3	6	100	....	6	177	....	....	.....	.....	.....
	ae	Am.-La France	3	4	75	....	6	177	....	....	.....	.....	.....
	ch ho	Am.-La France	3	4	70	1,400	35	32	....	....	.....	.....	.....
	ch ho	Am.-La F. (4)	1	..	...	....	...	...	....	....	.....	.....	.....
	tr st	Am.-La F. (4)	1	..	...	....	...	...	....	....	.....	.....	.....
Belleville	pp ho	Am.-La France	3	4	75	1,200	6	32	....	....	.....	.....	.....
Bernardsville	pp	Am.-La France	1	..	...	....	...	...	....	....	.....	.....	.....
Beverley	pp ch ho	Am.-La France	½	..	...	....	...	...	....	....	.....	.....	.....
Bloomfield	pp	Am.-La France	½	..	...	....	...	...	....	....	.....	.....	.....
Bogota	ch ho	Brockway	1	4	42	1,400	40	32	....	....	.....	.....	.....
Bound Brook	ch ho	Brockway	1	4	42	1,400	40	32	....	....	.....	.....	.....
Burlington	tr	Am.-La France	½	4	70	....	...	...	....	....	.....	.....	.....
Camden	tr	Am.-La France	3	6	100	....	6	177	....	....	.....	.....	.....
	ae	Am.-La France	3	4	75	....	6	177	....	....	.....	.....	.....
	pp ho	Am.-La France	3	6	100	1,200	6	32	....	....	.....	.....	.....

MOTOR TRUCK OPERATION AND ACCOUNTING XVIII.

By Charles A. Dickens.

One of the very best reasons why more pleasure car salesmen and regulation truck agency salesmen do not sell more trucks to the contractor is because they are not only minus on what motor trucks must do under given conditions in the contracting business but because they bemuddle their contractor prospect with the needless talk on worm, double-chain, internal gear, double reduction axle and four-wheel drive twaddle! They try to make up for their ignorance of operating conditions on contracting work by befogging the mind of their prospect with unessential drivel regarding governors and differentials and brakes and clutches and transmissions.

REQUIRES SPECIALTY EFFORT.

Many of these salesmen know how to surround a pleasure car order and many of them can sell trucks for the delivery of department store parcels, but that is not saying that they can register an equally successful record in truck sales to contractors. Until such time as they have the desire and patience to become as thoroly conversant with the contractor's problems (and the conditions under which he must operate), as they are conversant with the mechanical "makings" of their truck, they had better not attempt it.

MUST WIN HIS CONFIDENCE.

The contractor knows his two-horse teams can haul from 3½ to 5 tons, from 15 to 25 miles per day, on smooth, hard roads and he has not forgotten that under certain conditions he has been compelled to use six to eight 2-horse teams to haul but two tons the same distance. That's why it pays to know what you're talking about (especially when you're talking to a man who does know), if you would merit his confidence. And until you win the contractor's confidence, you are further away from an order than before you started. That's why it would have been far better for your manufacturer if you had not started at all.

MUST FIT PERFORMANCE REQUIREMENTS.

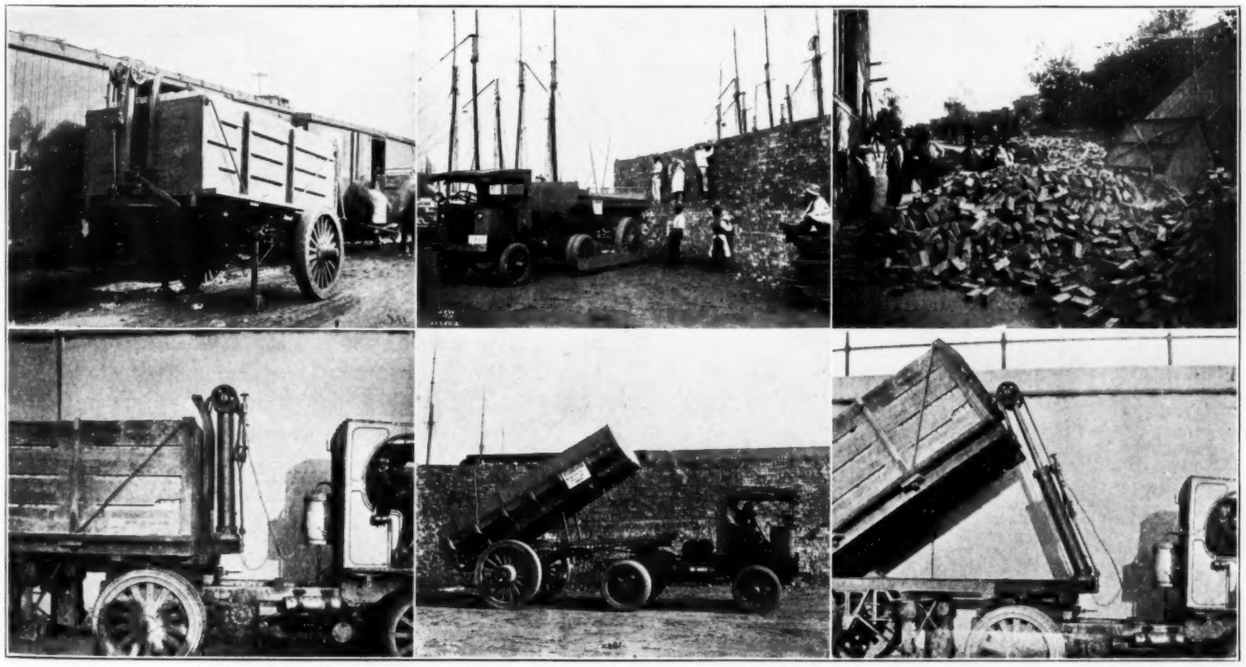
There are scores of truck makes to choose from, and still more scores of sizes and types to still further confuse. That's why I'd keep out of mechanical arguments until he wanted my truck. I'd first instill a desire to operate my truck by conclusively proving that it would save money over present methods and I would refer to the engineering features involved only in so far as it was necessary to prove that my truck was best suited to fit the performance requirements of my prospect's problems. In other words actual developed horse-power per pound of total weight carried at given speed would help me in proving a certain point as would chassis weight and construction (including body weight allowance), required to carry a given load under his conditions. I would only talk quality of materials and perfection of parts as considered in regard to the work in question.

TALK IN CONTRACTING TERMS.

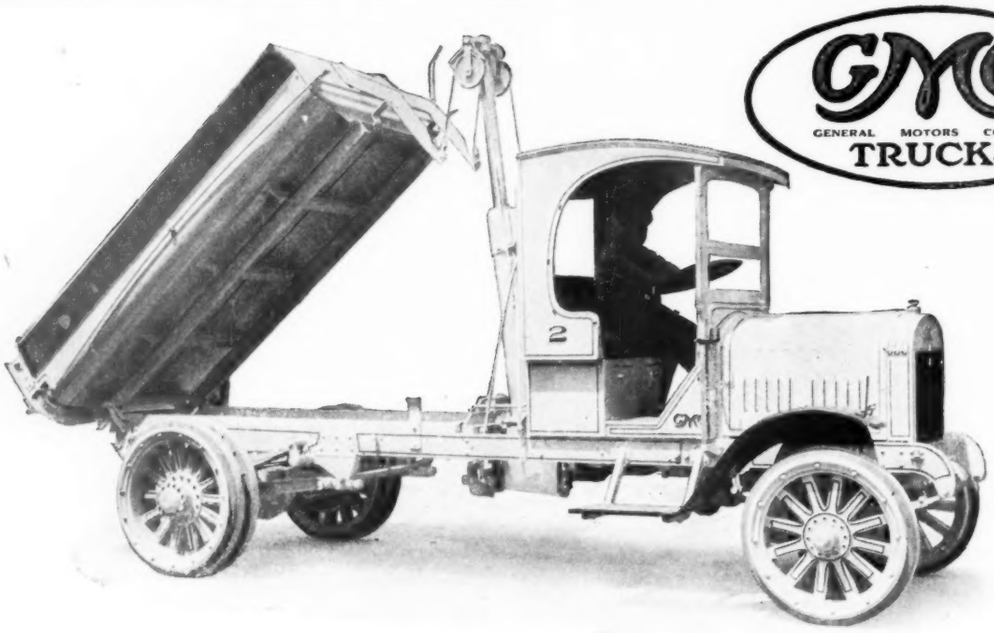
There is a truck language but I would talk trucks in plain, everyday contracting terms—the only language the contractor understands. I would not befuddle and confuse him with technical jargon (a matter which concerns him little and concerning which he cares less).

I would, however, prove that my make of truck fitted the special requirements of the contractor I was talking to. But I would first make sure of that contractor's requirements.

I would not compare truck and horse costs on a 'per day" basis because truck performance is so far ahead of horse performance that I'd be killing my strongest talking point. I'd not forget that the "cost per mile" method is almost as



GARFORD TRACTOR AND SPECIALLY DESIGNED TRAILER AS OPERATED BY THE STANDARD BUILDING SUPPLY CO., BROOKLYN, N. Y., IN TRANSPORTATION AND UNLOADING OF BRICK.



GMC Trucks Win Highest Rating

In City of Chicago Competitive Test For Trucks

When the City of Chicago buys Motor Trucks the Commissioner of Public Works is instructed to ask for bids and to award contracts to the manufacturer showing the highest rating based on the following points:

1—Price.
2—Service Facilities.
3—Inspection and Testing of Parts and Material.
4—Practical Experience with Truck by Others.
5—Responsibility of Manufacturer.
6—Comparative Cost of Repair Parts.
7—Motor.
8—Clutch.
9—Transmission Gear Set.
10—Final Drive.
11—Axles.
12—Frame.
13—Springs.
14—Wheels and Size of Tires.
15—Brakes.
16—Steering Gear and Arrangements.

The trucks are given a comparative marking on the basis of 100 points made up from the above sixteen important features.

The last three purchases of motor trucks by the City of Chicago were awarded to the General Motors Truck Company over all competitors, for in three successive tests GMC received the highest rating. Read the requirements again carefully. The City of Chicago is buying motor trucks on the basis of actual merit.

Write for complete information regarding the performance of GMC trucks now used by cities and towns throughout the country.

"Let your next truck be a GMC"

GMC Trucks are Built in Six Sizes. ¾- to 5-ton Capacity

New York, Boston, Chicago,

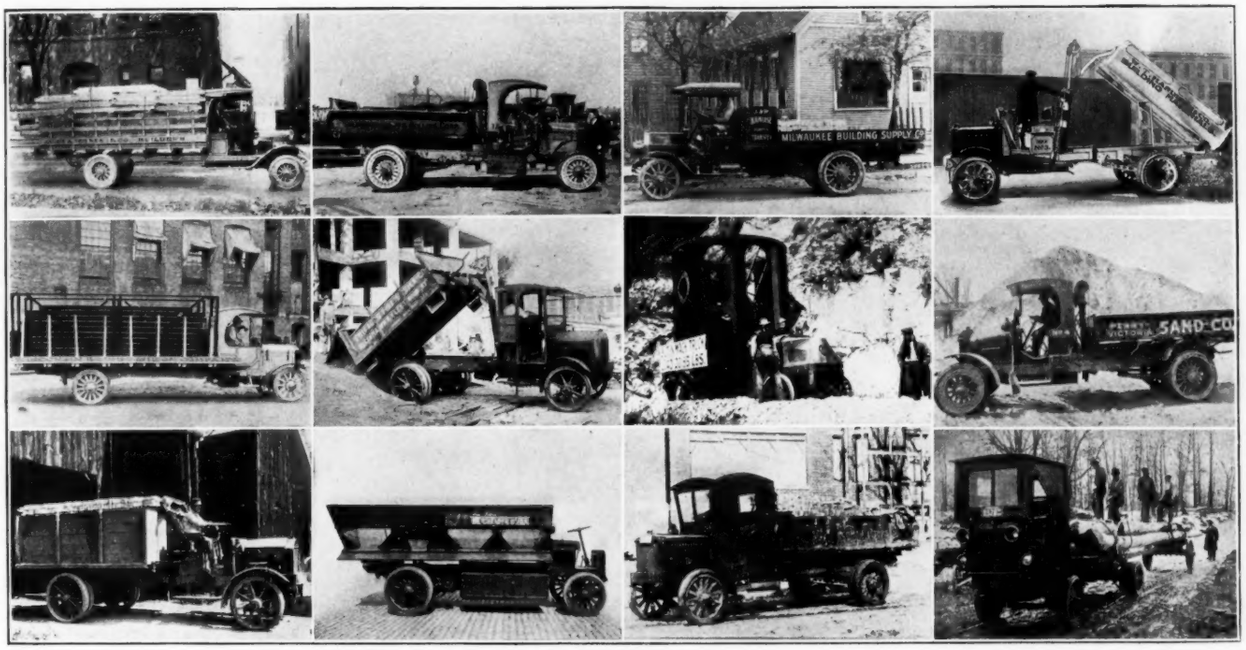
GENERAL MOTORS TRUCK COMPANY

One of the Units of General Motors Company

PONTIAC, MICHIGAN

Philadelphia, St. Louis.

(150)



MOTOR TRUCKS AS USED IN BUILDING AND BRIDGE CONSTRUCTION.

SIGNAL MOTOR TRUCK, AS OPERATED BY JAMES A. MOYNES & CO., OSWEGO, N. Y.

STERLING MOTOR TRUCK, AS OPERATED BY THE WISCONSIN BRIDGE & IRON CO., MILWAUKEE, WIS.

UNITED MOTOR TRUCK, AS OPERATED BY A WELL-KNOWN CHICAGO, ILL., BUILDING CONTRACTOR.

PIERCE - ARROW DUMP TRUCK, AS OPERATED BY HOLBROOK, CABOT & ROLLINS, NEW YORK, N. Y.

UNITED DUMP TRUCK, AS OPERATED BY THE CHICAGO FIRE BRICK CO., CHICAGO, ILL.

ATLANTIC ELECTRIC TRUCK, AS OPERATED BY BATCHELDER BROTHERS, NEW YORK, N. Y.

STEGEMAN MOTOR TRUCK, AS OPERATED BY J. & W. KRAUSE, MILWAUKEE, WIS.

MACK MOTOR TRUCK, AS OPERATED ON TEST ON 20% GRADE UP MT. WILSON, CAL.

FEDERAL DUMP TRUCK, AS OPERATED BY M. J. WALSH & SONS, HOLYOKE, MASS.

FEDERAL DUMP TRUCK, AS OPERATED BY W. T. HARDISON & CO., NASHVILLE, TENN.

PIERCE - ARROW DUMP TRUCK, AS OPERATED BY THE PERRY-VICTORIA SAND CO., BUFFALO, N. Y.

G M C TRUCK, AS OPERATED BY A BIG NEW YORK STATE BUILDING CONTRACTOR.

unfair to the truck for the reason that actual tonnage moved is not credited. I'd put my best foot forward at ALL times and talk in "Costs Per Ton-Mile."

And that's why you must talk trucks to the contractor in a language he can understand. He has sweat blood in his fight to wring out a profit thruout his gradual transition from the human muscle to the machine way of grading and crushing and mixing. He now realizes that to bid low at a profit to himself he must substitute steel muscle for mule and horse sinew.

DEPENDS ON THE CONDITIONS.

The motor truck can not be considered a transportation "cure-all" for all haulage problems encountered in the contracting business—it all hinges on conditions.

No two jobs are exactly alike—simply because the conditions encountered on no two contracting jobs are identically the same.

From the standpoint of draw-bar pull performance, you may say that the horse-motor is not more than 2 per cent. efficient as far as heat units are concerned, whereas the gas motor transforms fully 75 per cent of its "meals" into performance. 'Tis true as far as the operation of hay-motor by most contractors is concerned, yet it all depends on the job you're talking about or the conditions under which the comparisons are made.

STUDY HIS HAULAGE PROBLEMS.

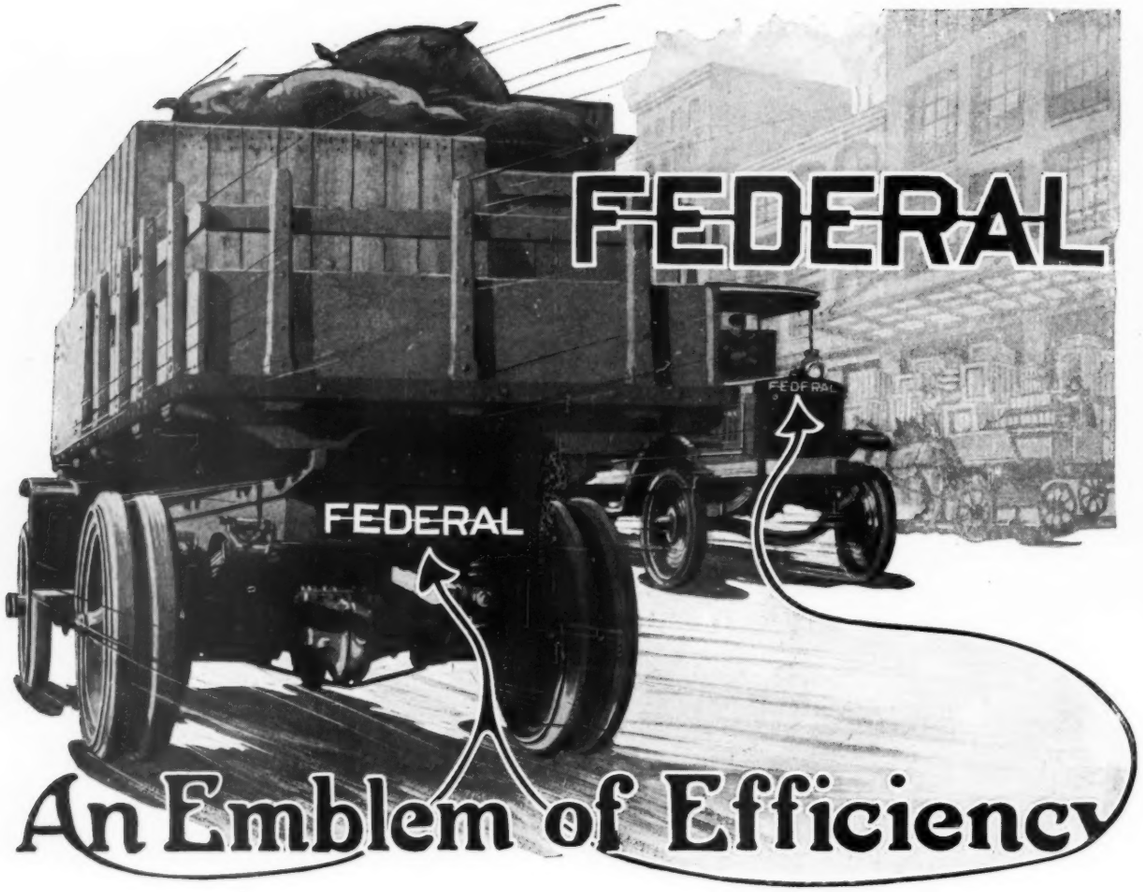
There is no doubt but that the vagaries encountered in contracting exceed those encountered in any other line of business and hauling costs have become one of the most important items entering into the total costs of a contracting job! That is why I would make a study of the contractors' hauling problem. I would understand (for myself) just why teams, or tractors, or trucks, or gasoline locomotives, or railway equipment, were most economical for certain kinds of contracting haulage, and under just what specific conditions. I would know the real reasons why (in each instance). I would ferret this information out for myself right "on the job."

GET OUT ON THE JOB.

I would become as thoroly conversant with the contractor's hauling problem as is the contractor himself. I would get out on the job with Mr. Contractor and stay alongside of him from morning until night. I would ride on the trucks and watch them perform. I would stick with the contractor in his office after hours and I would keep at it until I could figure costs intelligently from standpoints of length of haul, capacity of outfit per trip, rate of speed, amount of time lost in loading and unloading, amount of time lost due to bad roads, breakdowns and varying operating conditions. I would do all of these things and more, realizing that until such time as I knew enough about the contracting business to make up a contractor's estimate, which would "get over" that I was not in a position to talk trucks to the contractor from "his side of the fence."

MAKE SURE OF YOUR REASONS.

Before advising the purchase of a specific capacity or type of truck to my contractor prospect, I would first make sure of the particular work it would be called upon to perform and I would know all about the conditions under which it would be operated. I would then make my suggestions and would



Business men know the value of a proven name. They choose with confidence the article whose *demonstrated worth* can be identified by the name upon it.

That's why the very name FEDERAL is a distinct asset to you. It is a real "emblem of efficiency." Past performance associates with FEDERAL Motor Trucks as certain a service as "Burroughs"—"Addressograph"—"Multigraph"—associate with their respective products.

When you buy a FEDERAL, you buy something more than "specifications"—something more than a "motor truck." You buy what a FEDERAL *can do for you* as demonstrated by what FEDERALS *have done for others* in the same line of business. You figure in known quantities when you figure on the FEDERAL.

Write for *"The Blue Book of Traffic"*—
Also *"Federal Traffic News."*

FEDERAL MOTOR TRUCK CO.
22 Leavitt Street. DETROIT, MICH.

Can You Imagine—

A city the size of Boston, Detroit, St. Louis, or San Francisco,

—a thoroughly modern city of the present time, doing its millions of dollars worth of business every day

—supplying its thousands of inhabitants with fuel, foodstuffs, household goods

—transporting its manufactured products to railway stations—receiving in return its thousands of tons of produce from distant points

—can you picture them doing all this with the horse-drawn haulage equipment of the last decade?

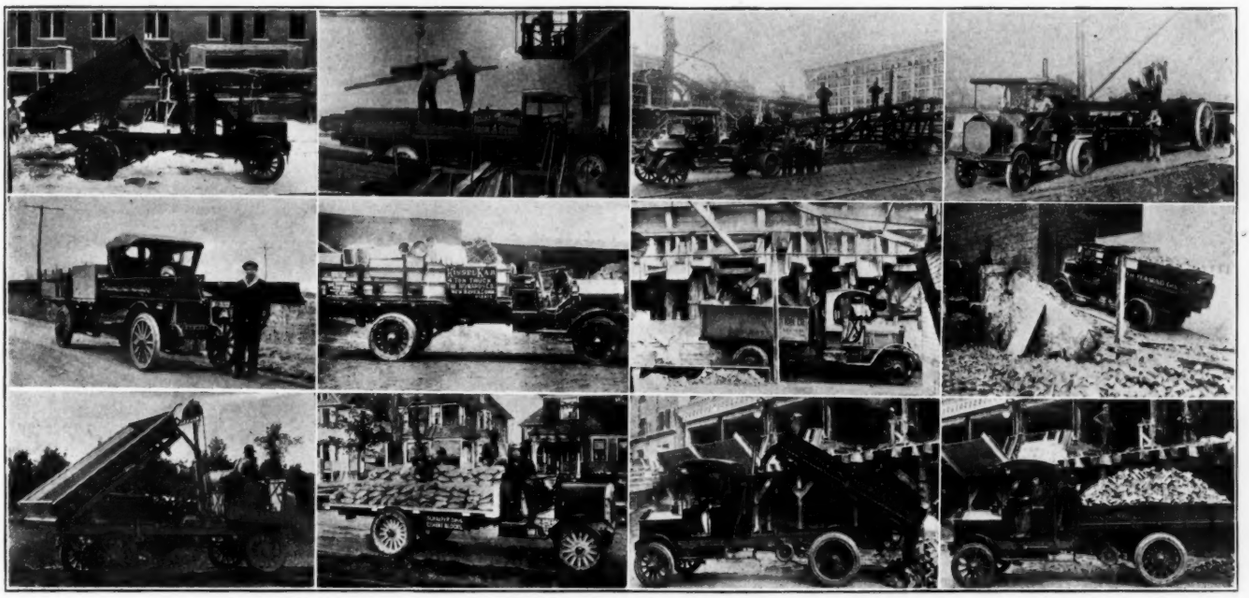
Equally important as the haulage habits of a city's daily commerce is the method by which the hauling of a city's various public service departments is conducted.

In Detroit alone, there are over 700 **Federal** trucks in commercial use. In addition to this number there are **Federals** used in several of the more important branches of the civic administration.

Each of these municipal **Federals** is doing its share towards speeding up the city's haulage, preventing the traffic congestion of the horse-and-dray era, serving the demands of a big municipality in a big, efficient manner.

Why not FEDERALS for the municipal haulage of YOUR city or town?

Write our Traffic Department for data on FEDERALS in municipal work in other cities. We shall also be glad to figure on the requirements of the various public service departments of your city.



MOTOR TRUCKS AS USED IN BUILDING AND BRIDGE CONSTRUCTION.

LEWIS-HALL DUMP TRUCK, AS OPERATED BY HENRY MINCEL, DETROIT, MICH.

FEDERAL MOTOR TRUCK, AS OPERATED BY THE BUFFALO GENERAL ELECTRIC CO., BUFFALO, N. Y.

4-WHEEL DRIVE DUMP TRUCK, AS OPERATED BY THE GARLAND BLOCK & SAND CO., YOUNGSTOWN, O.

PACKARD MOTOR TRUCK, AS OPERATED BY ROEHM & DAVISON, NEW YORK, N, Y.

KISSELKAR MOTOR TRUCK, AS OPERATED BY THE HOWARDS CO., NEW HAVEN, CONN.

KISSELKAR MOTOR TRUCK, AS OPERATED BY THE SCHAEFER BROTHERS, BUFFALO, N. Y.

STEGEMAN MOTOR TRUCK, AS OPERATED BY THE E. E. GILLEN CO., MILWAUKEE, WIS.

HURLBURT DUMP TRUCK, AS OPERATED BY THE LITCHFIELD CONSTRUCTION CO., NEW YORK, N. Y.

LEWIS-HALL DUMP TRUCK, AS OPERATED BY JAMES WALLS, INC., NEW YORK, N. Y.

KNOX TRACTOR WITH SEMI TRAILER, OPERATED BY THE GOODMAN CONTRACTING CO., NEW YORK.

GRAMM-BERNSTEIN DUMP TRUCK, AS OPERATED BY THE TIMROTH TEAMING CO., CHICAGO, ILL.

LEWIS-HALL DUMP TRUCK, AS OPERATED BY JAMES WALLS, INC., NEW YORK, N. Y.

give my reasons—all of them. And not until then would I be in a position to practically advise as to required capacity, proper weight and power of truck, needed road clearance, efficient body equipment, etc. The more practical my suggestions the nearer I would come to solving my prospect's individual problems, the closer I would be to his order. It takes more than "just talk" to sell trucks to contractors.

I would never "make a town" without spending some of my time on a construction job on which trucks were used, and it would make no difference to me whether these trucks were the product of my manufacturer or not. I would "cram" myself with actual "Short Cuts in Contracting" until helpfully practical truck information fairly oozed out of me at every pore!

WHY "IT ALL DEPENDS."

Motor trucks can be put into successful operation on any road and under almost any conditions under which teams and wagons can be used. Motor trucks will carry their greater loads up steeper grades on which teams cannot secure traction—and then some!

But, remember, that the word "road" in the contracting business is a misnomer—many times it is not even a trail—rather it is a nightmare, a rock-ribbed ditch or undulating stretch of boulders, jagged crags, chuckholes, sand pits, sudden drops and trenches—one wheel in a three-foot rut and the other somewhere on the crest of another!

A five-ton truck operating continuously on a new asphaltic concrete boulevard "may" safely carry more than its rated capacity, but the same truck operating on worn-out pavements and discouraging roads and chuck-hole trails, as encountered in contracting service, "may" not safely carry more than two-thirds of its rated capacity. That's why a five-ton truck is not always a five-ton carrier—it all depends.

LOT DEPENDS ON DRIVER.

Contractors feel that their past experience has qualified them to select the proper team or wagon best suited to their needs, but as regards trucks they are not quite so sure. That's why I would first merit their confidence by proving (via my selling talk) that I know what I am talking about. All of which is the same as saying that they will be more apt to take my word for it when I have convinced them that I know more about the operation of trucks on contracting work than they do.

The cost of operating a motor truck (like that of any other piece of machinery) depends a great deal upon the operator. That is why I would do all in my power to see to it that my new contractor customer hesitated before placing an ordinary team driver on his truck. A skilled truck driver not only knows how to increase truck performance per diem, but how to hold operating costs down to the minimum.

TRUCKS AT WORK ARE TRUCKS THAT PAY.

There is no longer any good reason why human muscle should be paid good money to shovel material direct from the gondola car to the truck. Such slipshod methods are not only wastefully expensive from the shovel standpoint alone, but result in costly truck delays and stalling at the car.

Time is money in the contracting business! A truck cannot wait like a team without excessive cost for loading and unloading! Quick loading and unloading are essential requisites to the economical operation of motor trucks!

Economical truck operation requires hauling conditions which make the ratio of running to standing time large, and high average speeds possible. The more instantaneous the loading or unloading device the more efficient the work of the truck.

HALL TRUCKS

They "*stand up*" under *your* operating conditions! They're built to fit *your* special performance requirements!!

The first ***Halls*** were made to meet the ***stringent*** specifications of the Russian Army—to withstand the most terrific mauling and cruel abuse of European war! And they ***did!***

And that superlatively high standard of construction has been maintained to the letter ever since!

For instance—the springs! Broader, larger, more substantial! Longer and more flexible! No stretching!! They ***bear*** the stress of heavy overloads!!

That's why ***Halls*** ride easy! The chassis construction is ***not*** racked and strained by inequalities of the road! ***No*** creaking and groaning and wobbling!

And the brakes are powerful—the axles doubly strong! Steering apparatus like the rest of the chassis, is built to withstand the ***most*** severe contracting service a truck may ever have to face, wherever or however it is used!

Built like steel Pullmans for sturdiness and safety! ***Hall*** Trucks are ***thoroughbreds*** in every inch from radiators to tail lights!

Get *your* copy of our book "Speeding Up"—NOW! Shows ***how*** to cut haulage costs!

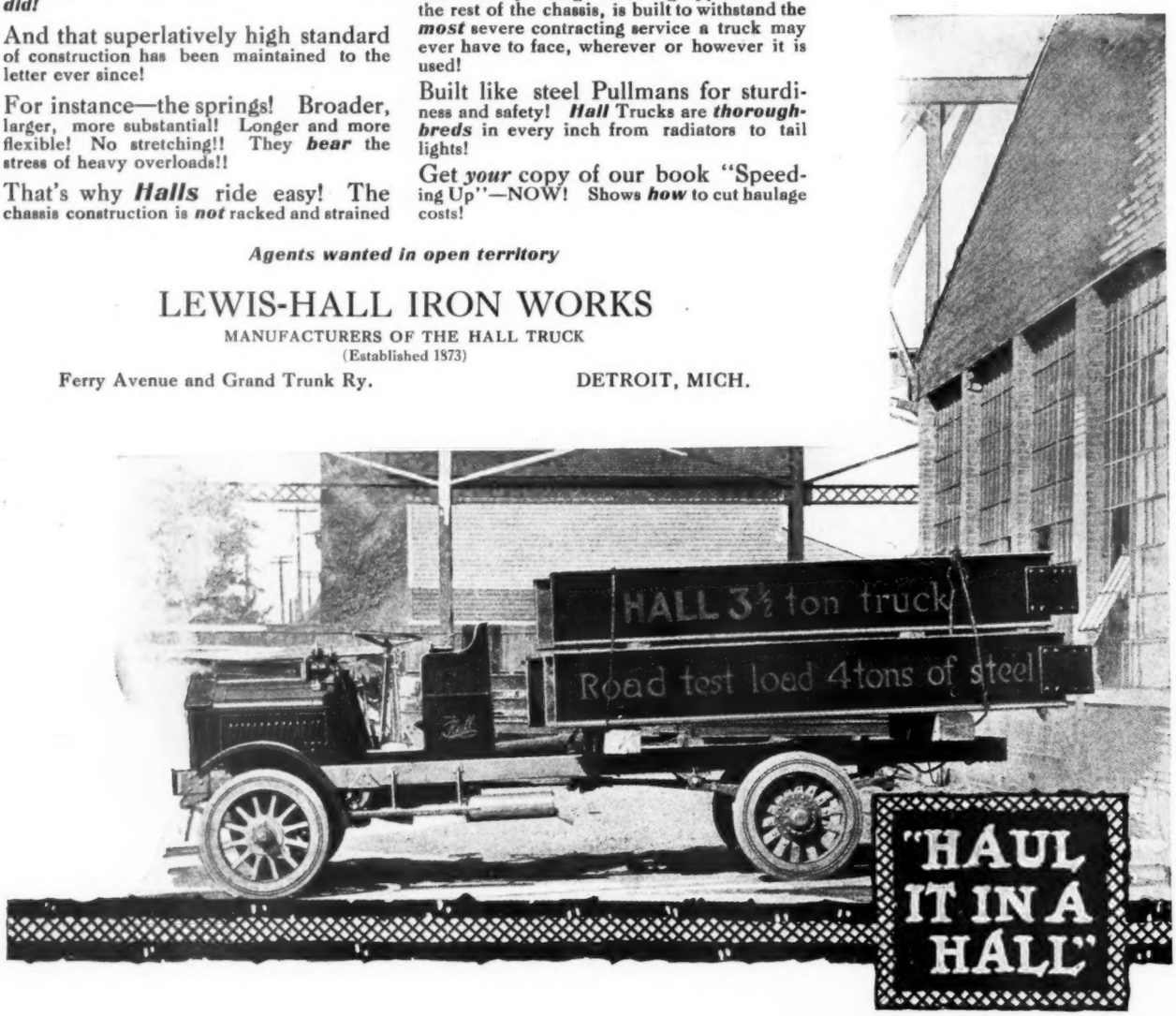
Agents wanted in open territory

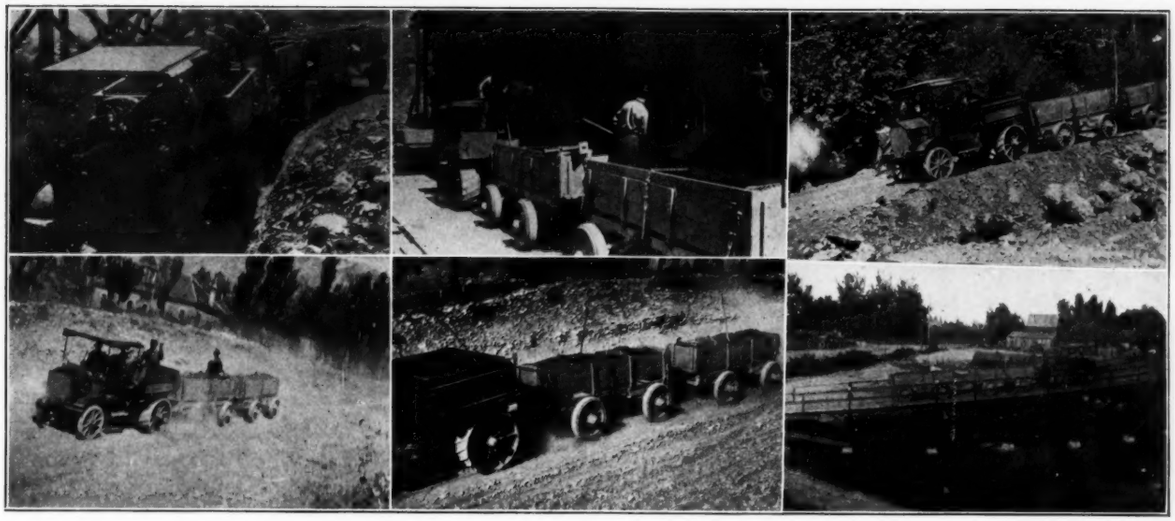
LEWIS-HALL IRON WORKS

MANUFACTURERS OF THE HALL TRUCK

(Established 1873)

Ferry Avenue and Grand Trunk Ry. DETROIT, MICH.





KNOX TRACTOR ON COTTONWOOD CANYON HAUL.

DROPPING UNDER BINS AT FORKS IN BIG COTTONWOOD. (18 PER CENT. PITCH IN 20 FEET.)

A 'FAIR' SAMPLE OF THE 'GOING.'

TRACTOR AND TWO TRAILERS AT THE LOADING BINS.

LOOSE GRAVEL HILL 12 PER CENT. GRADE. TRACTOR PULLING 4,300 LBS. OF COAL.

TRACTOR AND TRAILERS HELD BY HYDRAULIC BRAKES ON 15 PER CENT. GRADE. MAXFIELD HILL.

SHOWING DOCKS WHERE COAL IS DUMPED INTO CARS BELOW.

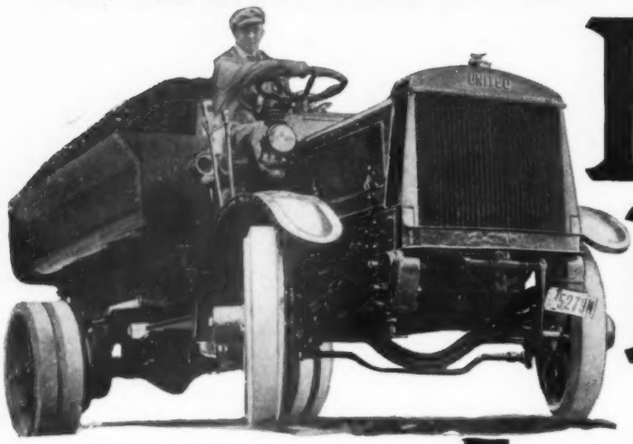
The busy truck is the truck that pays the biggest dividends. That's why I would not only make it a point to recommend the use of loading and unloading devices, but I would know exactly why I was so advising. Instead of "airing" my own opinions, I would talk specifications as to why and how Pat McNulty or Frank Casey or Mike Ponderelli did this or did that. I would state their problems tersely and explain just why they did this or did that. And I'd show the Dollars and Cents Savings they made. I would state their problems tersely and explain their solution minutely. I would show my prospect actual action photographs of the ways and means employed by these progressive contractors in keeping their trucks constantly on the move.

ADVOCATE THE SHORT CUTS.

Certain old-fashioned contractors hold that quick loading methods are impossible in handling spoil from excavation except in cases where steam shovels and trains are operated—but they are wrong, and every day the most successful contractors operating motor trucks are proving that they are wrong—that's why I would talk from the standpoint of the man who makes good in a tight pinch. You cannot get around the record which can be verified. I have yet to find the contractor who will not listen to the experience of the other fellow—he always wants to find out if the other fellow has anything on him, and he is always ready to consider a method which is practical enough to increase the profits of his competitor.

JEFFERY QUAD HAULING 22,410 POUNDS FOR THE MOTOR TRUCK AND TERMINAL COMPANY FROM LOS ANGELES TO SAN PEDRO HARBOR, CAL.

Cut Down Your Hauling Expense



In municipal work, *one* big item of expense is the hauling. Yet is the *one place* where a big saving is possible.

It may not be possible to cut down the general expenses very materially—but by getting the materials transported in less time and with less help, you can make a big saving every trip and greatly increase your profits.

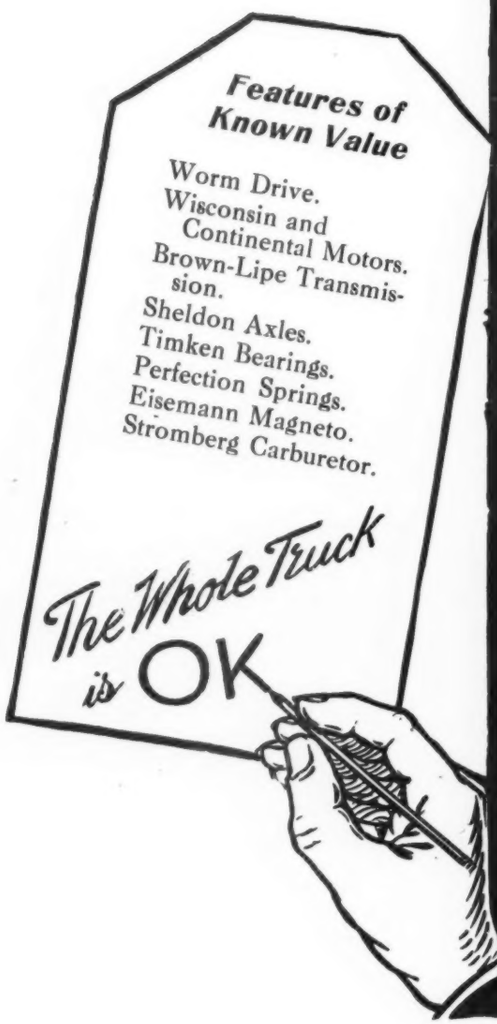
Actual use has proven that **United Trucks** cut down the hauling expenses to a very appreciable extent. They have the power to move the heaviest loads in quick time—the strength to stand the unusually severe strain encountered on *extra* rush jobs—the endurance and stability to insure years of hard service.

And with our special dumping bodies and hydraulic hoist, unloading takes but a few seconds. This feature alone means a big saving in time and labor.

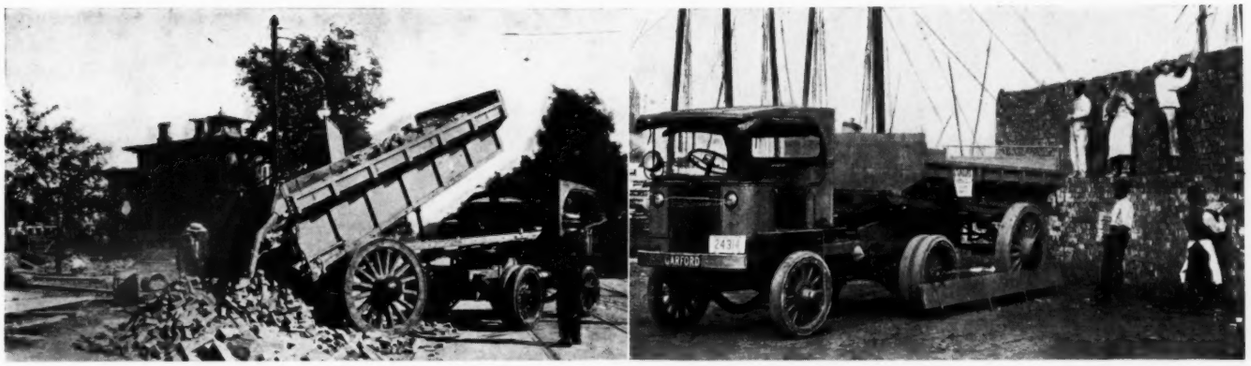
Start in right now to cut down hauling expenses with the **United Truck**—the product of America's foremost engineers. We are prepared to make prompt delivery. Write us for full details.

UNITED MOTORS CO.

690 North Street. **GRAND RAPIDS, MICH.**



United Trucks



GARFORD 10-TON TRACTOR, AS OPERATED BY THE STANDARD BUILDING SUPPLY CO., NEW YORK CITY, IN HAULING AND DEPOSITING OF BRICK. THIS SPECIALLY DESIGNED OUTFIT ELIMINATES MUCH OF THE DELAYING DRUDGERY OF BRICK HANDLING.

The Average Contractor suffers no special pang to see his team standing idle, but you must change all this. You must systematize his transportation. You must advocate short cuts in loading and unloading. You must in many cases talk traveling belts, gravity chutes, slides, grab buckets or detachable bodies. It all depends on conditions, but you must show your contractor prospect how to load his trucks in a fractional part of the time in which he used to load his old horse wagon. Prove that your plan means more performance at less cost—(profits for him)—and he'll motorize! He'll buy your trucks!

OVERLOADING MEANS TRUCK SUICIDE.

Overloading not only results in excessive strains and a greatly accelerated rate of depreciation, but in unnecessary high maintenance cost.

Overloading affects frame, springs, wheels, axles, tires, power plant and even the driving mechanism—and while the truck is designed with a certain factor of safety, this factor was intended merely for emergencies, and not for continuous and continual abuse.

I would never miss an opportunity to prove via actual incidents that overloading means motor truck suicide! While it is true that the fatigue of steel is much slower than that of flesh tissues, the fatigue is there just the same. Remember it was the one extra straw that broke the camel's back.

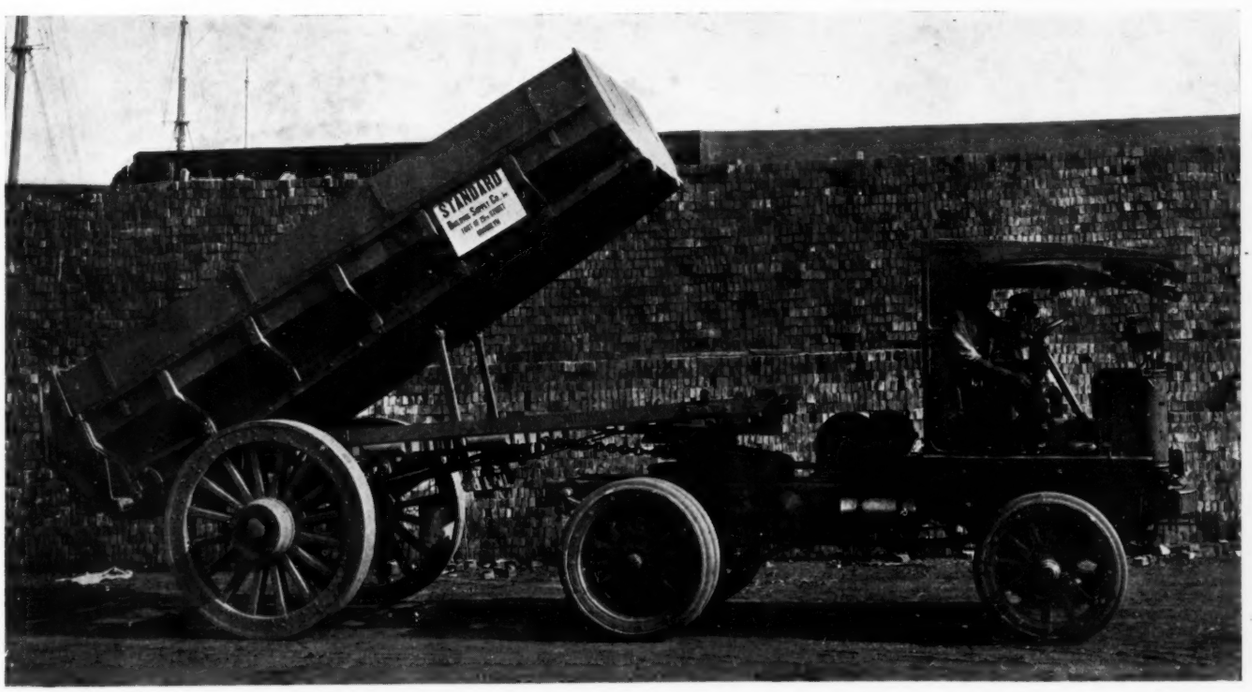
OVER-SPEEDING HASTENS CRYSTALIZATION.

Truck over-speeding results in excessive strains and a greatly accelerated rate of depreciation. I would make it plain that the advantages of motor truck haulage over horses was not only a matter of speed, but rather the gain accruing from constant operation in all sorts of weather at any time of the day or night.

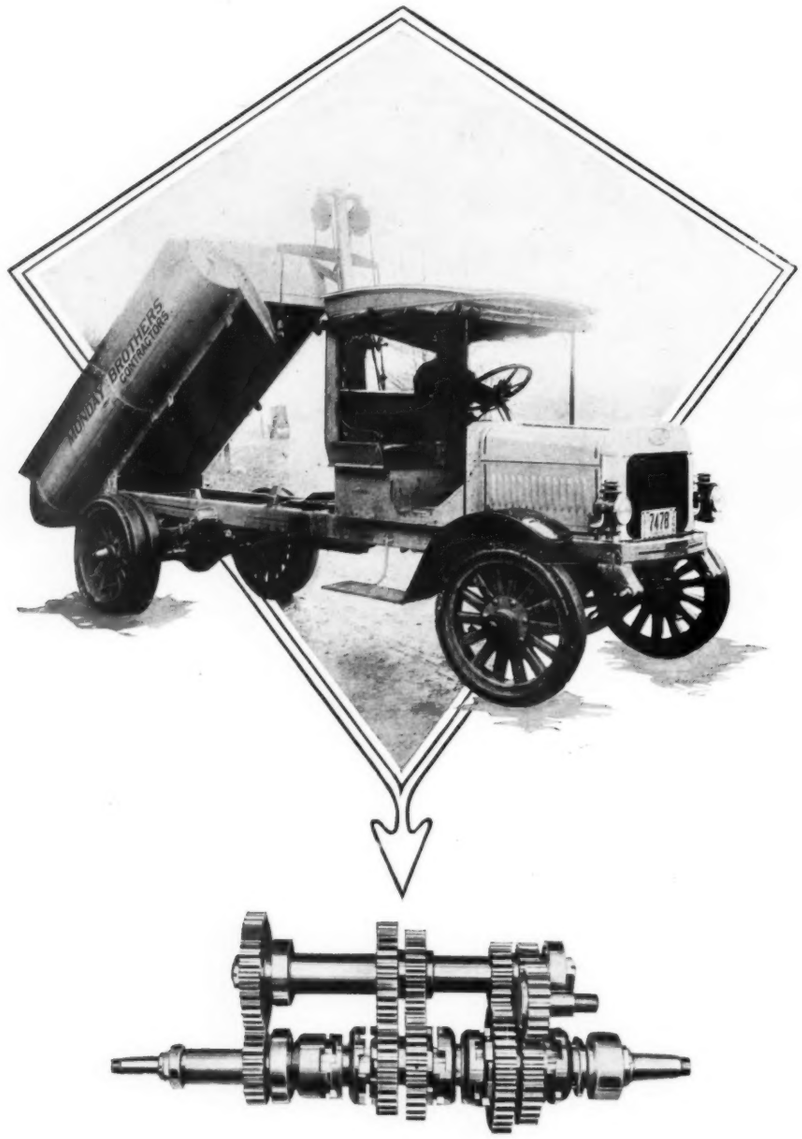
I would study the speed and load situation from the angle of my contractor owners—and I would arrive at an approximately average speed at which it would be safe to drive a loaded truck over certain types of roads without a serious increase of repairs.

TRUCK JOY-RIDING IS COSTLY.

Upkeep and depreciation are serious items to the contrac-



CLOSE VIEW OF GARFORD TRACTOR AS SHOWN AT TOP OF PAGE. SPECIALLY DESIGNED 10-TON TRAILER, WHICH IS POWER OPERATED FROM THE TRACTOR ENGINE AFTER THE MANNER OF AUTOMATIC DUMP BODY. THE AUTOMATIC WINCH ENABLES THE DRIVER WITHOUT LEAVING HIS SEAT TO CAREFULLY DEPOSIT HIS LOAD OF BRICK AT ANY GIVEN POINT OR POINTS BY THE TOUCH OF A LEVER.



A truck is no stronger than its transmission. The G-B transmission is the strongest transmission in the World! That's why G-B trucks are strong trucks!

All gears in a G-B transmission are always in mesh—they cannot strip, chip or crack. Shifting is done with rugged dog clutches. That's one reason why G-B Trucks give continually good service over bad roads as well as the good!

When the G-B Transmission is at low speed the leverage is so great that the truck easily climbs hills and goes through sand and mud the ordinary truck would be afraid to attempt!

No jerks and jars. And a considerable amount of wear on tires and all parts is prevented! Verily we say the G-B Transmission approaches 100% efficiency under all conditions encountered in the contracting business! Send for its Autobiography.

Gramm-Bernstein Motor Truck Company

LIMA, OHIO, U.S.A.

HURLBURT 7-TON SIX-CYLINDER WORM TRUCK, AS OPERATED BY THE LITCHFIELD CONSTRUCTION CO., NEW YORK CITY.

tor operating heavy machinery and the relation between efficiency and speed is of equally vital importance. That's why the over-speeding of heavily loaded trucks in rough-and-tumble fashion is every bit as dangerous as truck over-loading. That's why I'd take pains to vividly picture the disastrous results of sending a heavy load jogging over rough pavements and railroad crossings at break-neck speed. The effect of constant shock encountered in forced output runs up the upkeep. While it is true that too slow a speed means a less number of tons and constantly increased cost per ton-mile, it is equally true that over-speeding means a greater tonnage at even greater cost per ton-mile. Motor truck joy-riding is a costly habit!

BIG TRUCKS FOR BIG WORK.

Highway contractors, in a number of states, have found, thru experience, that the large capacity truck is most profitable; materially cheaper than a lesser capacity truck as far as maintenance and operation are concerned! They are thru with the cheap, makeshift contraption that looks like a gasoline apple-cart!

How much should a truck weigh? I do not know. It should weigh enough, however, to enable it to successfully perform its work—day in and day out and year in and year out and at the minimum outlay for operation and maintenance (performance and satisfaction considered) and with a minimum depreciation in value after years of service.

CONTRACTING SHOWS UP CONSTRUCTION.

When accidents happen to contracting machinery it is too late to find out what broke first! War may test a truck, but the contracting business proves it!

Strength plays an important part in the usable life of a truck, but accuracy of workmanship is as important! True alinement of all parts to reduce friction and a good oiling and cooling system have much to do with it.

I would convince my prospect that in purchasing my trucks he was not buying so many pounds of iron and steel. I would make him realize that I was selling him Service—and I would see to it that he got it.

I would know just why trucks of moderate size are most economical and convenient for handling men, small machinery, tools and supplies, as well as small odd hauling jobs. Many truck salesmen think they know. But they don't! They're guessing!

THE BEST IS NONE TOO GOOD.

Don't think that any kind of a truck is good enough for the contracting business! Long, continuous (day-in, day-out), dependable service is what counts. A truck "on the job" is worth any number of trucks in the repair shop. The con-

PIERCE-ARROW 5-TON TRUCK, AS OPERATED BY THE McKELVY-HINE CONSTRUCTION CO., YOUNGSTOWN, O. WORKING AGAINST A TIME FORFFEIT OF $250 TO $350 A DAY, THIS TRUCK DELIVERED AN AVERAGE OF 225 TONS DAILY FOR 125 WORKING DAYS. THIS TRUCK DELIVER9D 290 TONS OF SAND IN 10 HOURS ON A ROUND TRIP HAUL OF 1 1-3 MILES.

Quality Construction Plus Quality Performance Equals *"On the Job."*

The claim of the SIGNAL MOTOR TRUCK for your business is not based upon any sensational exploit or any sensational feature. It is based upon two things only (*a*) quality construction all through (*b*) quality performance in daily service.

The quality construction is evidenced by the use of exclusively quality units such as Continental Motors, Timken-David Brown Worm Drive Rear Axles, Ross Steering Gear, Brown-Lipe Transmission, Eisemann Magneto, Detroit Self-Lubricating Springs, Stromberg Carburetor.

Equally important with the quality of the units is the careful engineering and the practical skill with which the various units are harmonized into one complete unit of remarkable strength, endurance and reliability, so that the uniform experience of users everywhere is quality performance in daily service—and the uniform report to those who inquire of users concerning **Signal Motor Trucks** may be boiled down into five words, "They are on the Job."

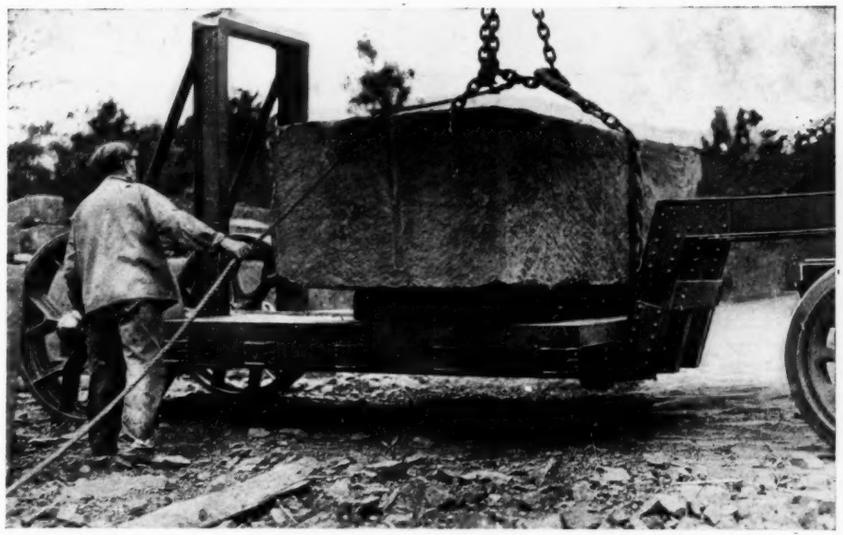
No matter what business you are in, no matter for what service you require a motor truck, the most important element you can buy in a truck is the ability to be "on the job."

Signal Motor Trucks are made in all sizes from 1 ton to 5 tons. Write for catalog and full information concerning the Signal line.

SIGNAL

MOTOR TRUCK COMPANY

DETROIT, MICH.



KNOX LOW-HUNG SEMI-TRAILER AND TRACTOR, AS USED IN THE HANDLING OF CUT STONE. LOADING PLATFORM IS BUT 26⅞ INCHES ABOVE THE GROUND. THE WEIGHT OF THE STONE BLOCK, AS SHOWN, IS 12 TONS.

tractor's truck must be "Johnny-on-the-spot" 365 days in the year!

The best truck is none too good for the hardest work on which a truck can be used—contracting haulage. My truck might cost more, but so does a sound, willing horse cost more than a spavined, wind-broken wreck.

Many trucks may be alike in appearance when viewed from a distance. Perhaps that is the reason so many contractors formerly selected inferior makes. They could not see the difference between a truck of doubtful merit as applied to contracting and one of superior qualities simply because the salesman did not understand the contracting business thoroly enough to make him see the truck after it had been working under his conditions. Consequently many contractors accepted the claims made by the price salesman representing the light, or cheaper truck, under the belief that he was saving money and getting the truck that would give the same kind of service that could be obtained from the higher priced truck.

Truck economy depends not upon what you pay for the truck, but upon what you get for what you do pay. Rightly considered, the purchase of the best truck for the construction business is the truest economy. Such a truck will last much more than twice as long as many trucks costing half as much. And what is more to the point, they will be worth more than twice as much in satisfactory service all the time.

THE "FIRST COST" FALLACY.

The best built truck (best suited to the working requirements) is the only truck the contractor can operate at less than team and wagon rates. It is "the cost to keep" that counts. The gruelling work of contracting hauling shows up a poorly designed truck, and the experience of most contractors who have tried to save on first cost has been most painful and decidedly expensive!

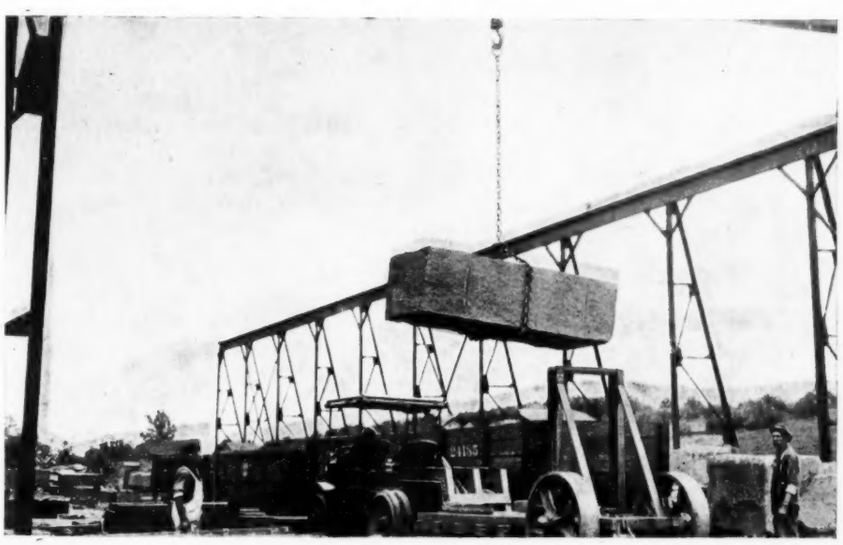
The truck made to meet the requirements of the contracting business need not be sold in price competition with the light or cheap truck made for the delivery of small store parcels.

The "first cost" saving is the ostrich way of figuring real truck economy. The only true way is to figure the ultimate cost of truck service—the cost per ton-mile. Bargain price "first cost" talk contains a joker! Veteran contractors know that. Serious minded contractors know it. Contractors who have operated trucks know it.

The "first cost" is the biggest cost of a good truck and that's the smallest cost of any other truck because of the after expense. The contractors' truck must stand up and deliver mileage enough to justify its first cost or its first cost at any price is a joke.

MEASURE VALUE IN TERMS OF USE.

It is no longer considered good contracting practice to burn



KNOX TRAILER AND TRACTOR (AS SHOWN ABOVE). TRACTOR CAN BE "JACK-KNIFED" AT A SHARP ANGLE UNDER THE SEMI-TRAILER. THIS OUTFIT CARRIED ITS 12-TON LOAD A DISTANCE OF THREE MILES IN EXACTLY TWELVE MINUTES.

The Knox Did It!

PHARAOH (and 3,000,000 slaves) consumed six months in dragging a stone block from Thebes to the Pyramids—a Miracle! Five-Ton Motor trucks and special traction tractors Fell Down on the Cardiff Haul! But "*The Knox did it!*" What's that? And the job was put put over on the "*Double Quick*," too!

The Cottonwood Canyon Trail (Cardiff Mining Interests, Salt Lake City, Utah) is one of the ***Most Severe*** in the Country! Five-ton motor trucks could haul but four tons down grade from the mine and ***Did Not even dare*** attempt the Up-grade haul!

But the Knox Tractor (Model No. 36) hauled sixteen tons per trip from the mine—as well as hauled four tons on the ***Rock-Strewn Up-grade Trail*** (a rise of 3,050 feet—grades as steep as 16%)! How's that?

Five (Special Traction) Tractors averaged but 45 tons per day—just ten tons more than the Average Daily tonnage haul of a ***Single*** Knox Tractor! How's that?

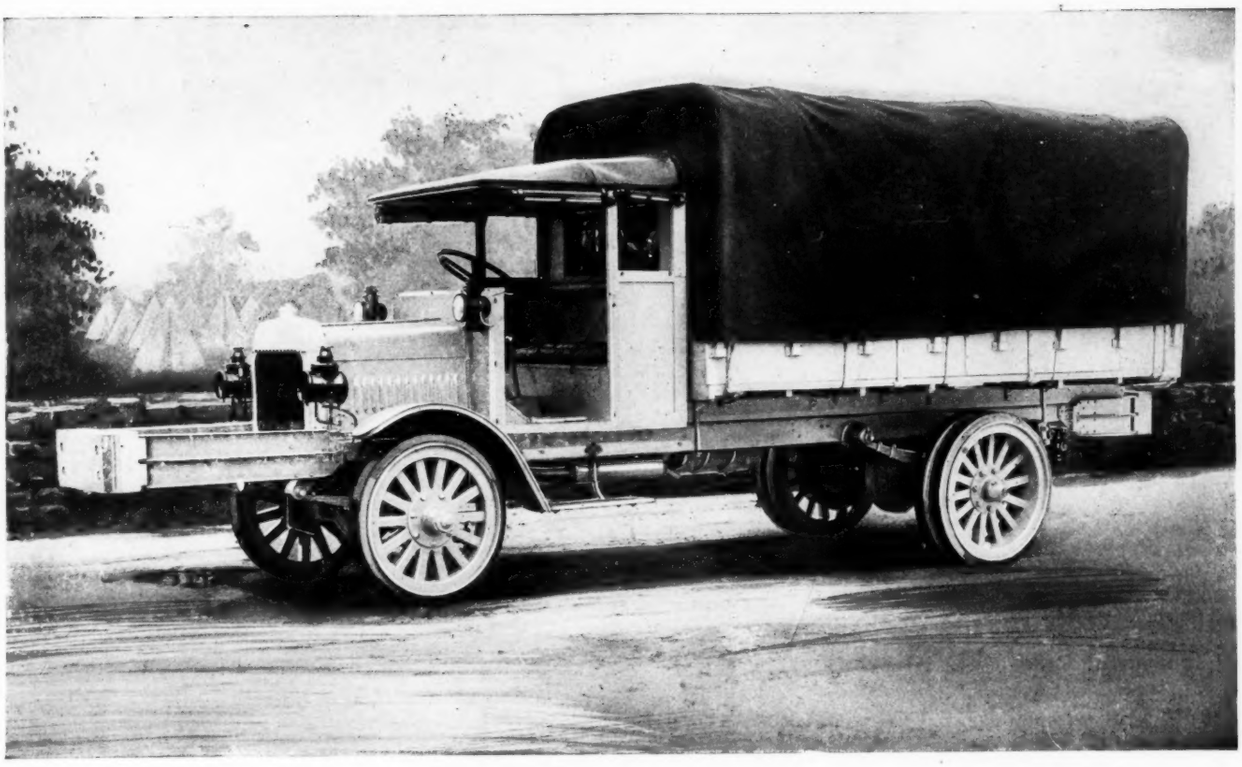
The Knox Tractor (on 11 round trips of 16 miles each —two trips every 24 hours) hauled 272,660 lbs. of ore and 27,080 lbs. of coal on an Average gas consumption of but 21 gals. per trip (two qts. of oil) ***in spite*** of Heavy Rainstorms and Tortuous Footings on 16% grades. And "*No* repairs were necessary"!

And at no time was it necessary to add water to the radiator on account of heating! "Radiator showed *No* sign of boiling at any stage"!

There is no Heavy Hauling or Trucking Problem you cannot *Solve* with the Knox Tractor! We'll gladly send Complete Story—illustrated.

KNOX MOTORS ASSOCIATES

SPRINGFIELD, MASS., U.S.A.



GRAMM 5-TON TRUCK, AS OPERATED BY ARMY DEPARTMENTS OF SEVERAL GOVERNMENTS.

up money nor is there a craze for mere cheapness among the great majority of contractors who really do good work. They are beginning to learn that it pays to measure value in terms of use.

Now the contractor has found out what the truck really is, he is beginning to buy real value—that is why price is no longer the prime consideration! The contractor who really does big things in a big way at a big profit to himself knows that real value depends on the cost of service rendered, not on the first cost. Final cost is more important than first cost. Upkeep charges are governed largely by the prices paid for parts.

You can buy a truck at almost any price you want to pay. My truck may be a little higher in price than some others—so also is a gold watch higher in price than a silver one. Still, all who can buy gold, buy it.

Tractor Hauls Ore From Mine to Smelter.

The United States Transportation Co., Murray, Utah, are operating Knox tractors in the hauling of ore from the bins of the Cardiff mines in the Big Cottonwood Canyon to the smelters in Salt Lake Valley. This decision was reached after eleven demonstrations by the Utah-Idaho Motor Company.

Following is a brief synopsis of results of these eleven demonstrations. The equipment consisted of one Model 36 Knox tractor with 5-ton ore body, and two 5-ton Troy trailers equipped with regular steering apparatus, roller bearings and 36 by 7-inch tires.

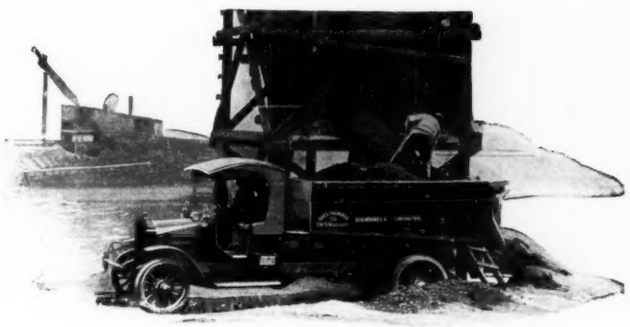
On the down trips from the mine the trailers were practically always held back by the brakes on the tractor, this being a remarkable performance, owing to the fact that in many places the grades are as steep as 16 per cent.

Traffic was never interfered with in any manner, on account of the fact that the tractor could pass as easily as the ordinary automobile. The tractor was equipped with steel wheels 14 inches wide, which were fitted with diagonal cleats. After the 11 trips up and down the canyon, no appreciable wear was noticeable on the tires. Some of the demonstrations were made during heavy rainstorms and no difficulty in negotiating the trip was encountered at any time.

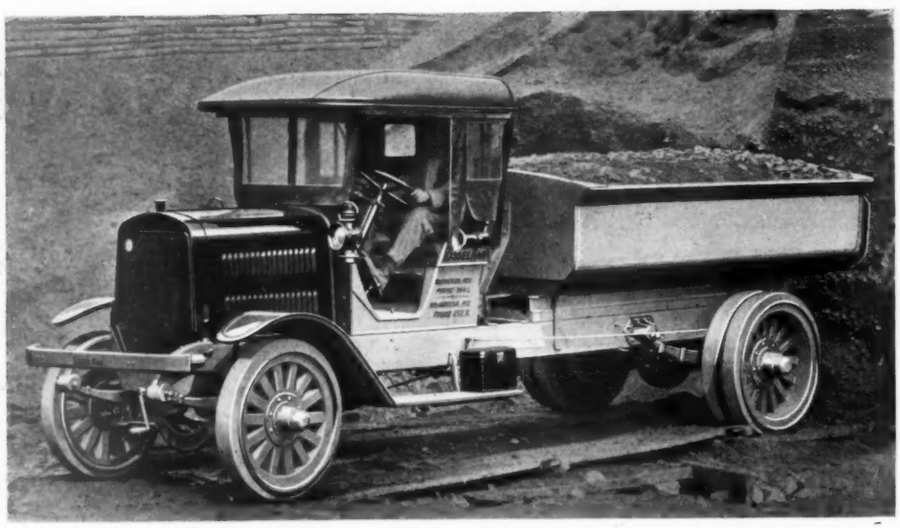
BIG TONNAGE HAULED.

The total tonnage of ore hauled during these eleven demonstrations was 272,660 pounds and altho coal was not taken back on every return trip, a total of 27,080 pounds of coal was hauled back from the valley up to the mines. The amount of coal hauled per trip ranged from 3,600 to 4,300 pounds. An average gas consumption of 21 gallons per round trip was registered and the round trip consumption of oil averaged 2 quarts.

Two trips were made every 24 hours, the average time coming down being 3½ hours and returning 4½ hours, which, with allowing 1 hour for loading and unloading, gave 3 hours for oiling, taking on gas and inspecting the machine. No repairs of any nature were necessary during the 11 trips. The distance covered on each trip down included 9 miles in the



PIERCE-ARROW 5-TON TRUCK AS OPERATED BY THE AMES TRANSFER CO., NEW YORK CITY, IN THE HAULAGE OF CEMENT, SAND, GRAVEL AND VARIOUS BUILDING MATERIALS.



"The market's most solid truck value at the price," **is the opinion of contractors in every part of the country who purchased KISSELKAR Trucks after a rigid investigation.**

The Kissel-built, *stand-up-no-matter-what-the-work-may-be* qualities, the ***power resiliency*** of the reliable Kissel-built engine, insure ***continuous*** and ***uninterrupted*** service at a ***minimum cost per ton per mile.***

Every KISSELKAR Truck has the same *Kissel-built* ***features and proved structural superiorities*** that have for the past ten years made KISSELKAR Trucks highly efficient in every line of contracting work.

There is a KISSELKAR Truck built in the exact size that will fit your requirements. Send for specifications and photos.

Kissel Motor Car Company

Hartford, Wis , U.S.A.

GARFORD TRACTOR, AS OPERATED BY FRANK J. CLANCY (CONTRACTOR), ASTORIA, LONG ISLAND CITY, N. Y. THIS VIEW SHOWS TRACTOR TOWING LOADED SCOWS TO DESIRED LOCATION FOR UNLOADING, THUS SAVING TUG HIRE AND DEMURRAGE CHARGES AMOUNTING TO $90 PER DAY.

canyon proper and 7 miles across the valley, which included one very steep hill.

One of the most remarkable features of the demonstration was the fact that at no time during the demonstrations was it necessary to add water to the radiator on account of heating. The radiator showed signs of boiling at no stage of the demonstration.

Considering that a rise of 3,050 feet is negotiated in this trip of 16 miles, seven of which are across the valley, the fact that the radiator did not overheat is even more remarkable. The difference in altitude seemed to make no difference whatever in the power of the Knox tractor engine.

COSTS OF OPERATION.

Following is a record of cost and maintenance covering operation for the first 30 days, as submitted by Mr. L. D. Stone:

Equipment—	
Two Knox towing-winch tractors	$10,800.00
Four Troy trailers (5-ton)	5,280.00
Bodies for trailers	200.00
Total equipment	$16,280.00
Fixed Charges, per 24 hours—	
Two drivers per car, at $5.00	$20.00
Two helpers per car, at $3.00	12.00
Depreciation, at 25 per cent	11.30
Interest, at 8 per cent	3.68
Insurance	1.00
	$47.98
Current Charges, per 24 hours—	
Gasoline, 84 gallons, at $0.25	$21.00

GARFORD TRACTOR (SAME AS ABOVE) PULLING SEMI-TRAILER LOADED WITH SAND (OR GRAVEL). MR. CLANCY STATES THAT THIS TRACTOR EASILY DOES THE WORK OF SEVEN HORSES. IT IS ALSO A "MOTOR MULE," AS SHOWN IN ILLUSTRATION AT TOP OF THIS PAGE.

STEGEMAN 6 SIX CYLINDER TRUCKS

Power Without Vibration

Makes the Six Master of the Situation

THE STEGEMAN is the only line of trucks powered with Six-Cylinder Motors. This has proved the most sweeping developement in the truck industry. A year's continuous tests have demonstrated the Stegeman Six-Cylinder undisputed master of the truck situation.

Leading S. A. E. Engineers declare the Six the superb power plant because the power impulses overlap, giving a continuous pull ***without vibration.***

Sizes:
1½
2½
3½
5 and 7
TON

A YEAR'S TESTS SHOW MORE POWER, LESS GAS

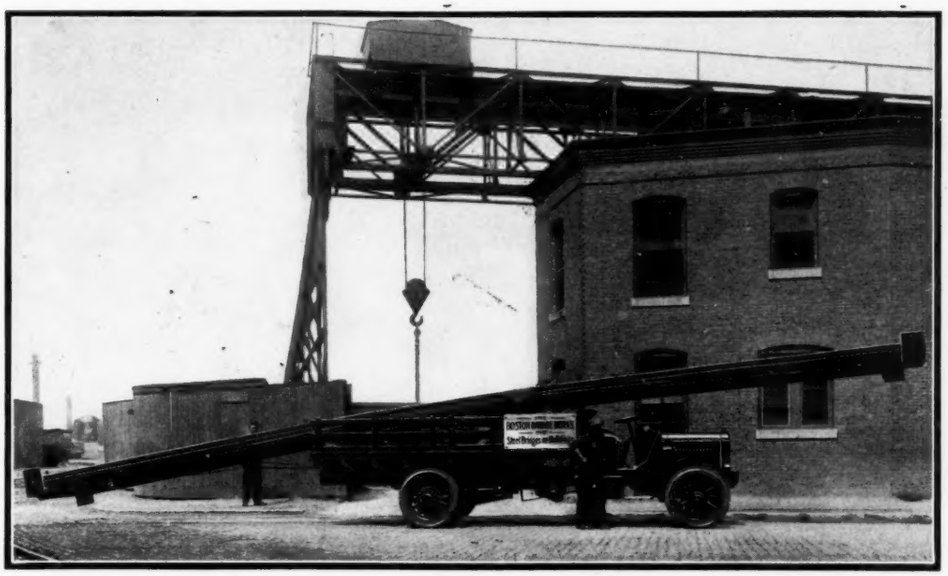
The Stegeman has stood the severest strain and stress of heavy duty service. McDonald of Red Rock, Arizona hauling ore and freight says, "I have grades averaging 25% and travel 100 miles each day over rough roads and get 5½ miles to each gallon of gas—hauling both ways". Hartje the Chicago Roadbuilder says, "I'm tickled to death with my pair of 7-ton Stegemans. They have tremendous power and drag any load I can pile on without vibration. They cost $1.00 per day less for gas and oil than any of my other trucks"

STEGEMAN AGENTS BEAT COMPETITION

The Stegeman Six has a bunch of selling proof and evidence. It's the truck with which you can sidetrack competition, because it possesses features buyers want—and other dealers can't supply. Write for vacant territory and selling plan.

Send today for our catalogue and circular on axle construction.

Stegeman Motor Car Co. Milwaukee



PACKARD 5-TON, AS OPERATED BY THE BOSTON BRIDGE WORKS. THIS TRUCK, 21 FEET IN LENGTH OVER ALL, HAULS MAMMOTH STRUCTURAL BRIDGE TRUSSES MEASURING 37 FEET IN LENGTH.

Oil, 2 gallons, at $0.50	1.00
Tires, at $0.08	10.24
Maintenance, at $0.05	6.40
	$38.64
Total cost per day	$86.62
On basis of 30 tons per machine per day (24 hours), cost per ton-mile	$1.45

"These figures," states Mr. Stone, "are based on the exact equipment used while I was there and there is nothing estimated. This does not include dock men or garage men or the transfer of the ore from the sleds on which it has to be brought part way out, but is the cost of actual operation while demonstrating.

"Some of the worst grades will scale 16 per cent. The 8 miles of canyon proper is all hill and runs from 8 and 10 per cent. to the above mentioned. The rest of the road (8 miles) is an average of about 4 per cent. with one or two hills, the worst about 14 per cent., and stretches of sand.

"Levendale is about 10 miles south of Salt Lake City, and the Transportation Co. now have their garage and station at that place. The ore is loaded from the tractors at this place into coal cars and taken to the sampler. This unloading is done over a tipple. I can safely say that this is the worst haul I have ever seen and I have placed trucks and tractors on some of the biggest contracts in the country."

Small Truck Pulls Sixteen Tons.

B. A. Dockery, contractor, Trenton, Mo., recently used his G. M. C. 1½-ton truck in pulling a trailer loaded with a 16-ton granite monument. "Two teams," states Mr. Dockery, "failed to budge the load. The truck, however, hauled the 32,000 pounds, mounted on a trio of house trucks, five blocks of the distance, unassisted. The horses helped up grades, however.

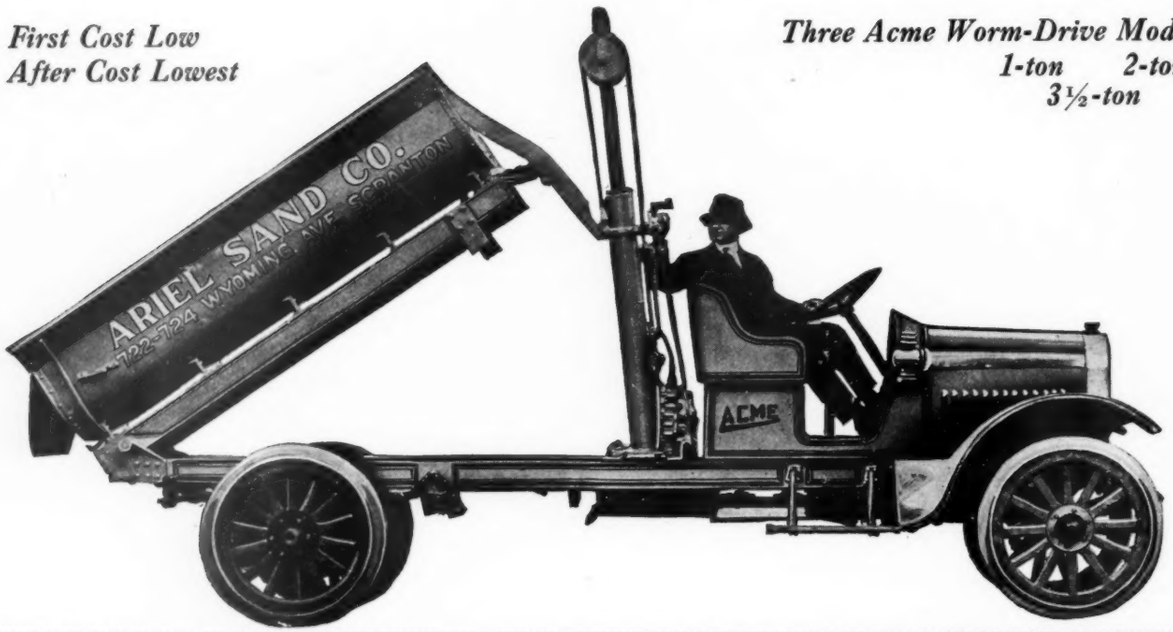
Resume of Itinerary Statistics.

Total time of trips	10 hours, 20 minutes
Total miles traveled	32.7
Total tonnage hauled	23.85
Total number of cans hauled	554
Total commercial ton-miles	157
Total time consumed in loading	5 hours, 39 minutes
Total time consumed in dumping	24 minutes
Net running time	2 hours, 17 minutes
Net average speed	3.2 miles per hour
Net average running speed	14 miles per hour
Average tonnage per load	4.77 tons
Ratio of running time to total time	22 per cent.
Average loading time	1 hour, 8 minutes
Average dumping time	5 minutes.

KNOX TRACTOR, AS OPERATED BY THE VERMONT MARBLE CO., SAN SABA, TEXAS. THIS VIEW SHOWS WINCH POWER OF TRACTOR BEING USED TO PULL 12-TON BLOCK OVER A STEEP PITCH ON A POOR ROAD.

First Cost Low
After Cost Lowest

Three Acme Worm-Drive Models:
1-ton 2-ton
3½-ton



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Put your problems up to **Acme** engineers. State loads to be carried, length of hauls, grades and general conditions. **Acme** engineers will supply exact haulage information—data based on actual experience.

Acme Trucks deliver continuous economy in every branch of contracting or municipal service. Long and short haul costs are effectively reduced with the swift, certain **Acme**—the truck that is 100% dependable. The performance record of **Acme** Trucks justifies their purchase—proves the wisdom of **Acme** selection.

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